No. 3.—*The Genera of Fossil Conchostraca—an Order of Bivalved Crustacea*[1]

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TABLE OF CONTENTS

[1]Published with the aid of a special gift from Mr. G. R. Agassiz.

INTRODUCTION

Dr. Frank M. Carpenter and Mr. Gilbert O. Raasch, while collecting Permian insects in Oklahoma, found many remarkably well preserved specimens of what are usually called Estheriidae. Mr. Raasch had intended to describe them, but since he has joined the armed forces, they have been turned over to me. I am indebted to these gentlemen for the privilege, but they handed me a problem for which there may be no satisfactory solution. A job which I thought would take about three weeks has occupied me for nearly two years, and most of the American species still await description. My efforts at this time have been confined to an attempt to describe the characteristics of the genera, and to list under them their various species. The study has necessarily been largely from the literature, and is subject to revision. Many of the published descriptions and figures are far from satisfactory. I have listed the described species in all cases where I could find the place of publication, but there are half a dozen mentioned by various authors who gave no data, and I have doubtless missed some papers, perhaps some important ones. My chief purpose in publishing this article at the present time is to point out that what paleontologists have called Estheria is not an Estheria, and that there are several easily recognizable genera in the complex which has passed under that name.

I am especially indebted to Professor Frank M. Carpenter, who not only furnished the specimens but made the photographs for the illustrations. Nor should I fail to mention the services of the librarians in the Museum of Comparative Zoölogy, who have been most helpful in hunting up obscure references and getting books from other libraries.

Relatively little attention has been paid to "Estherias" in North America, except for those in the Triassic of Pennsylvania, Virginia, and North Carolina. Even these are poorly differentiated and need reexamination. It is, however, known that conchostracons are present in our Devonian, Carboniferous, and Permian strata, and they are well worth study. Even this preliminary investigation shows that some of the genera have restricted vertical ranges, and a more critical study of the species would probably show that they are really useful in correlation and in the identification of particular strata. A great desideratum in the study of non-marine formations is a group which is widespread, and which contains species which are definitely identifiable. Pruvost has used the Conchostraca to a certain extent in France and Belgium, but he and other workers have been handicapped by the extremely generalized work of T. Rupert Jones, who for many years dominated this field and who had liberal ideas as to what constituted a species.

As an appendix to this introduction, for it had to be tucked in somewhere, I would add that I have adopted the transliteration Chernyshev, which Dr. Nabokov tells me is the correct one, for the famous and really productive Russian who is listed in bibliographies more commonly as Tchernyshev, or Tchernychev, or more rarely as Tschernychev. For many years the Russians were more familiar with French or German than with English, and unfortunately the transliterations differ in the three languages.

ESTHERIA A HOMONYM

Paleontologists seem to have overlooked the fact that the generic name Estheria was first used for a fly from Nova Scotia by J. B. Robineau-Desvoidy in the year 1830.[1] The genotype is *E. tibialis*, a species found not only in Nova Scotia but in New England. Professor C. T. Brues tells me that it is, curiously enough, an insect parasitic on crustaceans.

In 1837, H. Straus-Dürchheim published an article[2] in which he described the genus Estheria, which he credited to E. Rüppell. Rüppell's name appears in print after the generic name, but the only portion of the paper which he actually signed is a paragraph appended

[1] Memoires presentés par divers savants a L'Académie Royal des Sciences de L'Institute de France, et imprimés par son ordre. Sciences Mathematique et Physiques. Tome deuxième 1830, p. 305.

[2] Abh. Senckenbg. Mus. vol. 2, pp. 117 and 126, 1837.

in square brackets. Most authors quote Estheria Rüppell, but some mention Estheria Straus-Dürchheim. It is of no moment now as to whom the name is to be ascribed, for it is obviously preoccupied. C. Rondani in his monograph of the Diptera of Italy, Vol. 5, 1862, p. 60, changed the spelling to Esteria, a fact of importance only to entomologists. The type of the crustacean called Estheria was *E. dahalacensis* Rüppell (or Straus-Dürchheim), a species which is found in the "Susswassersumpfen" on islands off the coast of Abyssinia, or what was Abyssinia in 1837. The popularity of the biblical Esther among the inhabitants of that region inspired the name.

A great many years passed before the fact that the name Estheria could not be used for a crustacean caused zoölogists any concern. It was not until 1898 that G. O. Sars gave the generic name Leptestheria to the group of which *E. dahalacensis* is the type. Two other genera, Cyzicus and Isaura were proposed in early days for "Estheria"-like crustaceans, but apparently do not precede Leptestheria. Isaura was preoccupied when proposed in 1842 by Joly,[1] having been used in 1826 by Victor Andovin,[2] but credited to Jules-Cesar Savigny, for a group of hexacorals. Savigny, however, used the French form Isaures, and it was not till 1844 that Agassiz[3] changed the name to Isaura.

It is a question whether Isaura is a properly described genus, either as a coral or a crustacean, but the matter is of little interest to the paleontologist, for the species involved are all modern.

Some writers have maintained that since Estheria Rüppell is preoccupied, Cyzicus should replace it. This name was proposed by J. V. Audouin,[4] who did not describe the genus, but assigned to it the two species, *Cyzicus bravaisii* nov. and *Limnadia tetracerus* Krynicki. Since the former appears never to have been described, *Limnadia tetracerus*, which is well known, is the genotype.[5] It is not at all like Rüppell's typical species of "Estheria," and cannot take the place of that name. For some reason, von Zittel[6] cited this genus with the spelling Cyziscus.

[1] Ann. des Sciences Naturelles, second series, vol. 17, 1842, p. 293.

[2] Description de l'Egypte, vol. 1, pt. 4, 1826, 229.

[3] Nomenclator Zoölogicus, 1844, Polypi, p. 14.

[4] Ann. Soc. Ent. de France, vol. 6, 1837, Bulletin (placed after last cover in M.C.Z. bound copy), p. x.

[5] Daday de Deés (Ann. des Sci. Naturelles, ser. 9, vol. 20, 1915, p. 278) unfortunately placed this species in his subgenus Gymnocyzicus.

[6] Handbuch Paleont., vol. 2, fasc. 8, 1885, p. 567.

MODERN CONCHOSTRACA

The most extensive work on recent conchostracans is that of Jenö Daday, otherwise known as Eugen von Daday, or Eug. Daday de Deés. He was a professor at the Superior Polytechnical School at Budapest, and published an elaborate memoir on the Cladocera, as well as shorter papers on other groups. His monograph of the Conchostraca was first published in 1913 in Magyar tudomanyos Akademia, Budapest, Matematika és természethedományi osztaley Ertekezések a termeszett, Köréból, vol. 31, pp. 559–601; vol. 32, pp. 49–145. This is in Hungarian, but the families and genera described can be gleaned from the Zoölogical Record, Volume for 1914. The work was republished with additions and deletions in Latin and French (and a little English) in the Annales des Sciences Naturelles, Paris, vol. 20, ser. 9, 1915, pp. 39–330; vol. 6, ser. 10, 1923, pp. 255–390; vol. 8, ser. 10, 1925, pp. 143–184; vol. 9, ser. 10, 1926, pp. 1–81; and vol. 10, 1927, pp. 1–112.

Unfortunately Daday died before this series was finished, so that the bibliography, to which constant reference is made, was omitted.

A list of the families and genera of the modern forms according to Daday is here appended to give paleontologists an idea of the variety of these crustaceans now living.

Family CAENESTHERIIDAE Daday de Deés

Genera, Caenestheria Daday de Deés, Caenestheriella Daday de Deés, Cyzicus Audouin, Eocyzicus Daday de Deés; Subgenera of Cyzicus, Trichocyzicus and Gymnocyzicus.

Family LYNCEIDAE Stebbing

Daday de Deés credits this name to Sayce, although it seems to have been proposed first by Baird for a group of Notostraca in which the genus Lynceus was not included. Stebbing appears to have been the first to place it on a proper footing.

Genera, Lynceus Müller (synonyms are Limnetis Lovén, Hedessa Lièvin), Lynceiopsis Daday de Deés. Subgenus of Lynceus, Eulynceus Daday de Deés.

Family LIMNADIIDAE Sars

Genera, Limnadia Brongniart, Eulimnadia Packard, Limnadella Girard, Limnadopsis Spencer and Hall.

Family CYCLESTHERIIDAE Sars

Genus, Cyclestheria Sars.

Family LEPTESTHERIIDAE Daday de Deés

Genera Leptestheria Sars. The genotype is *Estheria dahalacensis* Rüppell, (or Strauss-Dürcheim), hence for modern species, this name replaces Estheria. Eoleptestheria Daday de Deés, Leptestheriella Daday de Deés.

De Deés' papers include descriptions of 152 species, almost half of which, 74, belong to the Caenestheriidae, whereas the Cyclestheriidae are represented by only a single species.

It should be remembered that this classification was proposed about thirty years ago, and some genera and species have been described since. A later important paper is that of K. H. Barnard in the Annals of the South African Museum, vol. 29, 1929, pp. 181 to 272.

In general, the classification of these animals is based upon the structure of the head and appendages, the shells being much alike. In fact, Daday de Deés gives a long list of species, and some genera which he says are incompletely known, and hence referred to particular genera and families with doubt. These are species described from the shells only. In some cases, he goes so far as to say that real identification is not possible unless both the males and females are known.

Few Paleozoic specimens retaining any traces of appendages have been found, and we have no sure way of distinguishing males from females. At the present time it would be unsafe to place any of the Paleozoic fossils in modern genera.

In only three instances have specimens with appendages been found, so far as I can learn. First are those described by Ph. C. Bill[1] from the Bunter sandstone of Alsace, and others by Miss Mabel Wright[2] from the Coal Measures of Kilkenny, Ireland.

Bill's specimens were poor, but those of Miss Wright are well preserved and of great interest. More recently Chernyshev has described a few Jurassic specimens of *Lynceus stuchukini* with fragments of appendages.

BASIS FOR DESCRIPTIONS OF THE FOSSILS

Lacking appendages and other unpreservable anatomical features, the fossils must be classified on the basis of the carapace. Unfortun-

[1] Mitt. der Geol. Landesanstalt von Elsass-Lothringen, vol. 8, 1914, p. 326, fig.
[2] Proc. Roy. Irish Acad., vol. 35, 1920, Sect. B, No. 9, p. 187, figs. 1–5, pls. 24, 25.

ately, the shells have few striking features. The outline of the valves, the curvature of the hinge, the position of the umbo, the presence or absence of a muscle scar, the spacing of the growth-lines, or concentric ridges, the presence or absence of radial markings, and the minute markings on the shell, reticulations, spinules, or puncta, are the only characteristics which the paleontologist can study.

Looking over the modern forms, (illustrated by Daday de Deés) on the basis of the characteristics listed above, it seems that all of the Caenestheriidae and two of the genera of the Leptestheriidae would be assigned to a single genus if known only as fossils. Leptestheria itself could be identified by its elongate, sub-rectangular shape. The Lynceidae lack growth lines, and the Limnadiidae have only a few. In the latter family the muscle scars are well developed and surrounded by a raised line except in Limnadopsis. In this genus the spines along the hinge are conspicuous. All the above have the umbos near the anterior end and have a more or less oval form. The last group, the Cyclestheriidae, have the umbo even further forward, so that the carapace is almost circular in outline, and there are few growth lines.

In the attempt which follows, the writer has employed various combinations of the shape of the carapace and the features of the surface. The outline may be circular, sub-circular, ovate, obovate, or subquadrate; the hinge may be straight or curved, the beak may be sub-central or in any position from that to really anterior; the axis of the greatest length may be parallel to the length or oblique.

As for the surface features, the concentric markings may consist of striae, lirae, costellae, costae, or undulations; these may be few or numerous, and the first one may be close to or at some distance from the beak. The radial markings may extend over the whole shell, or may be confined to the spaces between the concentric ones. In the latter case they are usually spoken of as "ornamentation." Many show no ornamentation except puncta; others have regular polygons, irregular polygons, irregular radial striae with ridges between them, and a few have regular radial lirae interrupted by the concentric markings.

These various features appear to have different taxonomic values in the various genera. The classification is necessarily artificial, and I have been conservative in erecting new genera. I have seen opportunities for many more, but have felt that since I was working chiefly from the literature, it would be better to make a bare outline to be revised by later students who have access to more material. In most cases I have made but the briefest possible notes about species,

giving only enough to provide some justification for the generic reference. It is now 84 years since Jones presented his Monograph to the Palaeontographical Society. It is time for someone to assemble specimens and write another.

TERMINOLOGY

Only a few technical terms are necessary in describing the rather featureless shells of the conchostracans. There are, however, a few words which I shall use which need explanations. The shell of most Conchostraca is not shed, but new increments are added from time to time. Since these new bands of shell are added above the previous edge, that is, anti-shingle-wise, the growth-lines are narrow depressions. These will be called growth-lines or concentric striations. Most of the fossils, and a few modern forms, have low, or even relatively high concentric ridges parallel to the growth-lines. If these are raised and linear, they will be called lirae. If broad and coarse, they will be called costae. Costellae are low, narrow, but rounded ridges. These terms are taken from modern usage in the brachiopods. Some of the fossils, but no recent conchostracans, have continuous, raised radial markings, which if fine, will be called radial lirae, if coarse, radial costae. Other members of the group, both fossil and recent, have radial markings between costellae, that is, in the intervales.

Because of the over-lapping of the increments of the shell, the internal casts show indented concentric striations which mark the anterior, not the posterior edge of each added band. Hence they are not actual growth lines, although they correspond in number to them. They may as well be known as pseudo-striae. The term intervale for the area between two concentric ridges is adapted from the usage of various French writers.

TAXONOMIC DESCRIPTIONS

Family CYZICIDAE Stebbing (emend. Barnard)

Bairdestheria gen. nov.

Caenestheriella Daday de Deés (*partim*), Math. és Termt. (see introduction for complete title), 1913, pp. 62–67, fig., pp. 570–574;– Ann. Sci. Naturelles, ser. 9, vol. 20, 1915, p. 106.

It is undoubtedly true that the nature of the spines on the telson is more important in classification than is the sculpture on the test, but

for paleontological purposes it seems necessary to subdivide Caenestheriella, leaving the strongly punctate forms in Daday's genus, and providing a new name for those species with radial markings between the lirae. In doing this we are merely reverting to Baird's[1] subdivision of "Estheria" into two groups:

"A. Valves of carapace dotted or punctate on the surface.

"B. Valves of carapace longitudinally striated on the surface." (It is obvious from his figures that by "longitudinally" he meant radially.)

Daday de Deés did not designate genotypes, and I have not seen the Hungarian edition of his paper. But one gathers from the Zoölogical Record, volume for 1914, that when Daday described the new genus Caenestheriella in 1913, he described only one species, *C. variabilis* sp. nov., hence this is the genotype. This is a strongly punctate form, belonging to Baird's group A.

It is Baird's group B which I now propose to segregate as a new genus, Bairdestheria, selecting as genotype, *Estheria donaciformis*, a living species found in Kordofan, southwest of Khartoum in Africa. Geological range, Jurassic to Recent.

Bairdestheria donaciformis (Baird)

Plate 1, figs. 1, 2.

Estheria donaciformis Baird, Proc. Zool. Soc., London, vol. 17, (for 1849), 1850, p. 89, pl. 11, figs. 5, 5a-c,—A. E. Grube, Ueber die Gattungen Estheria und Limnadia, etc., Berlin, 1865, p. 41, pl. 8, figs. 1–3, 7; pl. 9, figs. 2, 3, 7, 12–14; pl. 10, figs. 1–9, pl. 11, figs. 8, 13.

Caenestheriella donaciformis Daday de Deés, Ann. des Sci. Naturelles, Zoölogie, ser. 9, vol. 20, 1915, p. 179, fig. 38a-p.

"Valvulae choncharum umbone lata, a margine anteriore valde remota, fere in medio marginalis sita, marginens dorsalem valde superante; zonis incrementi 35–40, senioribus columnalite transverse granulatis, intervallisque angustis, pellucidis, transversalibus. . ."

The types were from Abeid, Korfodan, Africa. Daday de Deés says that Grube gave the best description of the species. Also that its distribution is limited to the zone of 30°–35° east longitude and 10°–15° north latitude.

So far as the shell is concerned, the diagnosis is:

Carapace oval, beak anterior in position, concentric lirae thin, raised, with radial striae in the spaces between them. The striae set

[1] Proc. Zoöl. Soc., London, vol. 17, (for 1849), 1850, pp. 84–90.

off irregular, discontinuous radial ribblets. Marginal setae generally present.

Other modern species are *Bairdestheria similis* (Baird), *B. packardi* var. *typica* (Spencer and Hall), *B. paradoxa* (Daday de Deés) *B. packardi* var. *cancellata* (Spencer and Hall), *B. ehrenbergii* (Daday de Deés),' *B. ehrenbergii* var. *dimorpha* (Daday de Deés), *B. ehrenbergii* var. *michaelsoni* (Daday de Deés), *B. indica* (Gurney), *B. annandalei* (Daday de Deés), *B. crinita* (Thiele), *B. elizabethae* (Sars), and *B. echinata* (Daday de Deés).

Bairdestheria transbaikalica (Chernyshev)

Estheria transbaikalica Chernyshev, Geol. and Prospecting Service, U.S.S.R., Bull. **49**, no. 10, 1930, pp. 70, 77, pl. 1, figs. 15, 16.

This species shows radial striations but no reticulations. It occurs in Siberia with *B.? reticulata* at a lower horizon in the Upper Jurassic than *B. middendorfi* which seems to have some of the characteristics of both.

Bairdestheria daja (Chernyshev)

Estheria daja Chernyshev, Journal of Geology, Institute of Geological Sciences, Acad. of Sci., Ukranian S.S.R., Kiev, vol. 7, no. 3, 1940, pp. 24, 40, pl. 3, figs. 46, 47.

The carapace is almost circular, an unusual feature in this genus. There are from 14–15 low costellae, with very fine striae and lirae in the intervales. The specimens are from the Jurassic on the Daya River above Shevya village, Transbaikalia, Siberia.

Bairdestheria? dahurica (Chernyshev)

Estheria dahurica Chernyshev, Geol. and Prospecting Service, U.S.S.R., Bull. **49**, no. 10, 1930, pp. 69, 77, pl. 1, figs. 11, 12.

Nothing in the description or figures gives any clue to the real characteristics of this species. The concentric lirae are numerous, 9 or 10 to the millimeter. It is said to be widely distributed in Transbaikalia and Mongolia, in strata supposed to be Upper Jurassic in age.

Bairdestheria? karpinskiana (Jones)

Estheria minuta (Alberti) var. *karpinskiana* Jones, Ann. Mag. Nat. Hist., ser. 5, vol. 12, 1883, p. 244, pl. 6, figs. 1a, b.

It is obvious that this form is not closely related to *"Estheria" minuta*. The concentric lirae are more numerous than in that species,

and the ornamentation on the intervales is definitely not reticulate. Jones described it as "in the form of minute, irregular vertical corrugations," which suggests Bairdestheria. It is from a formation of undetermined, but probably early Mesozoic age in the district of Troizk, on the eastern side of the Urals.

Bairdestheria sinkiangensis (Chi)

Estheria sinkiangensis Chi, Bull. Geol. Soc. China, vol. 10, 1931, p. 215, pl. 1, figs. 10a, 10b.

Age undetermined, but probably Upper Jurassic; China.

Bairdestheria kotahensis (Jones)

Estheria kotahensis Jones, Palaeontographical Soc. London, 1863, p. 81, pl. 2, figs. 24, 25. Jurassic?, India.

Bairdestheria murchisoniae (Jones)

Estheria murchisoniae Jones, Paleontographical Soc., London, 1863, p. 100, pl. 3, figs. 1–12.

Jurassic (Oxfordian), Scotland.

Bairdestheria? reticulata (Chernyshev)

Estheria reticulata Chernyshev, Geol. and Prospecting Service, U.S.S.R., Bull. **49**, no. 10, 1930, pp. 70, 77, pl. 1, figs. 13, 13a, 14.

This name appears to cover two species, one with closely spaced, the other with distinctly separated lirae. The intervales are said to show meshes, more or less hexagonal in outline. This would indicate reference to Euestheria, were it not for the resemblance to *Bairdestheria middendorfii*, which combines the reticulate and irregular radial ornamentation. It is supposed to be Upper Jurassic in age, and is found in Siberia and Mongolia.

Bairdestheria middendorfii (Jones)

Estheria middendorfii Jones, Palaeont. Soc., London, 1863, p. 111, pl. 4, figs. 12–22;—Eichwald, Lethaea Rossica, vol. 2, pt. 2, 1865, p. 1181;—Reis, Explor. Geol. Chem. de long du Chemin de Fer de Sibérie, liv. 29, 1910, p. 40, pl. 2, figs. 24, 25, pl. 4, figs. 19, 20, 23;—Cockerell, Bull. Am. Mus. Nat. Hist., vol. 51, 1924, p. 132, pl. 2, fig. 2;—Chernyshev, Geol. and Prospecting Service, U.S.S.R., Bull. **49**, pp. 67, 77, pl. 1, figs. 7–10;—Chi, Bull. Geol. Soc. China, vol. 10, 1931, p. 206, text fig. 1, pl. 1, figs, 1a, b.

Estheria orientalis Eichwald, Lethaea Rossica, vol. 2, pt. 2, 1865, p. 1183.

Jones published excellent drawings of this species, and Chernyshev's photographs corroborate them. A peculiar feature of the sculpture in the intervales is the combination of polygons and radial markings. Chi also noted this.

There has been considerable discussion about the age of the beds in Siberia and China which furnish the specimens. Jones supposed them to be Tertiary, but Chernyshev relegated them to the Upper Jurassic. Chi may be correct in his determination that they are Cretaceous.

BAIRDESTHERIA SUBQUADRATA (Sowerby, emend. Jones)

Cyclas subquadrata Sowerby, Fitton's Strata below the Chalk., Trans. Geol. Soc., ser. 2, vol. 4, pt. 2, 1836, pp. 177, 345, pl. 21, fig. 8.

Estheria elliptica Dunker, Programm. hoh. Gewerbschule, Cassel, 1943, p. 41;—Monog. Norddeutsch Wealdenbildung, 1846, p. 61, pl. 13, fig. 33;—Jones, Paleontographical Soc., London, 1863, p. 103, pl. 3, figs. 18–29, pl. 4, figs. 1–7.

Estheria subquadrata Jones, Geol. Mag. ser. 3, vol. 7, 1890, p. 389, pl. 12, figs. 1, 2a, b.

Sowerby gave no description of his species but published a figure of a young shell with a small but prominent smooth umbo and numerous concentric costellae. About 16 can be counted on the figure. The beak is almost central.

Dunker described *Estheria elliptica* in 1843, but did not figure it until 1846. His figure shows the same subcentral position of the beak as does that of Sowerby, but the costellae are much further apart, and only 6 are present. He gives the length as from 3.5 to 5 lines, and the height as about $\frac{3}{4}$ the length.

It is fortunate for us that Jones received specimens of this species from Dunker and was able to collect at Sowerby's type-locality. No one working from the literature alone would have suspected that the forms described by Jones were in any way related to those figured by the earlier authors. Why Jones used the German name *elliptica* is another puzzle. The figures in the Monograph of 1863 show that at least two species are involved in this complex, possibly more. One specimen from Germany (pl. 4, fig. 2) has the subcentral beak shown by both Sowerby and Dunker, but figs. 1 and 3 certainly represent two other species. The English specimens (pl. 3, figs. 18–29) are probably all one species. The anterior position of the beak is not what one would expect from Sowerby's figure of the type of *Cyclas subquadrata*. We can only take Jones' word for that identification.

The German specimens were found in a black shale of Lower Creta-

ceous age in Hanover. The English ones were from Sussex, where they occur at three horizons in the Wealden.

Bairdestheria kansuensis (Chi)

Estheria kansuensis Chi, Bull. Geol. Soc., China, vol. 10, 1931, p. 214, pl. 1, figs. 9a, 9b.

A peculiar sculpture, partly radial, partly polygonal, characterizes this species, which is from the Lower Cretaceous of China.

Bairdestheria nengkiangensis (Chi)

Estheria nengkiangensis Chi, Bull. Geol. Soc. China, vol. 10, 1931, p. 213, pl. 1, figs. 8a, 8b.

The large figure (8b) is obviously that of the cast of the interior of a left valve. It is interesting to note that the pseudo-striae are on the crests of the concentric undulations. This is the same sort of preservation as is common in Palaeolimnadiopsis, but it has no evolutionary significance. The sculpture on specimens with the shell preserved is of the type to be expected in members of this genus. Lower Cretaceous, China.

Bairdestheria intermedia (Chi)

Estheria elliptica var. *intermedia* Chi, Bull. Geol. Soc. China, vol. 10, 1931, p. 210, pl. 1, figs, 6a, 6b, 7, 11.

This species is referred to Bairdestheria chiefly because of the nature of the sculpture. It is a Lower Cretaceous form from China.

Bairdestheria sinensis (Chi)

Estheria middendorfii var. *sinensis* Chi, Bull. Geol. Soc. China, vol. 10, 1931, p. 209, pl. 1, figs. 2a, 2b, 3a, 3b, 4, 5.

This species is allied to *B. middendorfii*, but the carapace is smaller. The sculpture is of the same type. Lower Cretaceous, China.

Bairdestheria posidomyoides (Chernyshev)

Estheria posidomyoides Chernyshev, Geol. and Prospecting Service, U.S.S.R., Bull. **49**, No. 10, 1930, pp. 65, 76, pl. 1, figs. 1, 1a, 2.

The concentric costellae are numerous, 7 to 8 in one millimeter. The age appears to be Upper Cretaceous, and the locality is on the Amur River in Siberia, a sufficiently vague location.

Bairdestheria amurensis (Chernyshev)

Estheria amurensis Chernyshev, Geol. and Prospecting Service, U.S.S.R., Bull. **49**, No. 10, 1930, pp. 66, 76, pl. 1, figs. 3, 6.

Three species, belonging to three genera, appear to be included in this species. The specimens represented by figures 3 and 6 are Bairdestherias. The subcentral beak of the specimen shown in figure 4 indicates that it is an Orthothemos, whereas the recurved growth lines of the individual shown in figure 5 are those of a Limnadopsis. The two specimens which remain in Bairdestheria have relatively few costellae.

The horizon and locality are the same as for *B. posidomyoides.*

Bairdestheria mawsoni (Jones)

Estheria mawsoni Jones, Geol. Mag. dec. 4, vol. 4, 1897, p. 290, pl. 11, figs. 3a–g, 4–6.

This typical member of the genus is from strata of unknown age in cuttings along the Bahia and San Francisco railroad at various localities between 12 and 85.5 kilometers from Bahia in Brazil.

Family LIOESTHERIIDAE nov.

Carapace oblong, ovate, or rarely subquadrangular or semicircular, with numerous lirae, costellae, or costae, which cover practically the whole surface of the shell. Radial or reticulate markings are present more rarely.

It is with regret that the writer establishes this family, which will include most of the older fossil conchostracans. He is compelled to do so, for both Daday de Deés and Barnard point out that the Cyzicidae (Caenestheriidae) cannot be distinguished from the Leptestheriidae on shell characteristics alone, and it is therefore not possible to assign the fossils definitely to either. There does seem to be one way in which most of the fossils differ from modern Conchostraca. That is the presence of concentric elevated markings of various kinds. Continuous radial ribs are entirely unknown among the modern forms. It should be noted also that in contrast to modern forms, it is difficult to see the real growth lines. It should be definitely understood that this family does not include all of the fossils.

Lioestheria Depéret and Mazeran

Soc. d'Hist. Nat. d'Autun, Bull. **25**, 1912, p. 167.

"Les formes dont l'ornementation consiste en costules concentriques, fines et serrées souvent inégales et plus ou moins fasciculées, donant á l'ensemble de la carapace un aspect homogène, ou même presque lisse; la structure du test dans les intervalles des costules parait consister en poncutations fines devenant polygonales á un tres fort grossissement, ou en un quadrillé fin extrêmement serré."

Depéret and Mazeran did not designate a genotype, but since they said: "C'est á ce groupe qu'appartainent *Estheria lallyensis*, décrite dans ce memoire. . . .", it is obvious that it was this species on which their subgenus was founded. I therefore select it as the genotype.

The authors, in discussing the relationships of their new species, remarked that it belonged to a special group of Estherias, beginning with *E. striata* Munster of the Carboniferous, its variety *E. striata munsteriana* Jones from the Permian, and which continued in Lower Jurassic with *E. concentrica* Bean and ended with *E. elliptica* Dunker in the Wealden. There are reasons for doubting this genealogy.

Pruvost[1] cited this subgenus as: "Group de l'*E. striata* (*Lioestheria* Depér. et Mazer.)", but this can hardly be considered as the designation of a genotype. He added *E. sub-quadrata* Sowerby to the list given by Depéret and Mazeran.

The generic characteristics seem to be those expressed by the original describers and by Pruvost, that is, they are Lioestheriidae of oval form, anterior beak, and with numerous extremely close-set costellae, so flat that they give the shell an almost smooth appearance. The intervales between the costellae have puncta only.

Lioestheria lallyensis Depéret and Mazeran

Plate 1, fig. 3

Estheria lallyensis Depéret and Mazeran, Soc. d'Hist. Nat. d'Autun, Bull. **25**, 1912, p. 167, pl. 5, fig. 1.

This species has from 20 to 22 fine, irregular, more or less fasciculate concentric costellae. The specimens were from the Permian at Lally, near Autun, in northeastern France.

Lioestheria crassa (Lutkevich)

Estheria crassa Lutkevich, Bull. Com. Geol. Leningrad, vol. 48, 1929, pp. 721, 729, pl. 36, figs. 12, 12a, 13, 13a, 14, 14a.

The numerous concentric costellae, 15 to 25 in number, depending

[1] Terrain Houiller du Nord et du Pas-de-Calais, 1919, p. 51.

on the size, indicate that this is a Lioestheria. Although the specimens were, in part at least, derived from a boulder, the age is thought to be Mid-Devonian. The localities are in southern Esthonia.

Lioestheria striata (Goldfuss and Munster)

Sanguinolaria striata Goldfuss and Munster, Petref. Germaniae, pt. 2, 1840, p. 180, pl. 159, figs. 19a, b.

Cardiomorpha striata de Koninck, Anim. foss, terr. Carbon. Belgique, 1842, p. 105, pl. H., figs. 9a–c.

Estheria striata Jones, Paleontog. Soc., London, 1863, p. 23, pl. figs. 8–18.

Estheria (*Lioestheria*) *striata* Pruvost, Terr. Houiller du Nord et du Pas-de-Calais, 1919, p. 52, text-fig. 13, pl. 24, figs. 20–23,—Mem. 44, Musée Royal d'Hist. Naturelle de Belgique, 1930, p. 194, pl. 10, figs. 5, 6.

This species has been reported from Germany, Belgium, France, and Scotland. It appears to be most common in the upper part of the Dinantian (this is the age of the beds at the type-locality, Regnitzlosau, near Hof, Bavaria), but it occurs also in the Westphalian.

Lioestheria mathieui (Pruvost)

Estheria (*Euestheria*) *mathieui* Pruvost, Ann. Soc. Geol. du Nord, vol. 52, p. 171, text-fig. 1.—Chi, Bull. Geol. Soc. China, vol. 10, 1931, p. 217, text-fig. 2.

The carapace is nearly as high as long, with numerous concentric costellae. Westphalian, China.

Lioestheria raaschi spec. nov.

Plate 1, figs. 4, 5

Carapace small, oval, highly convex, with the beak near the anterior end. Costellae numerous, not greatly elevated, regularly arranged, with narrow intervales between them. At the umbonal region they are so slightly elevated that this area seems almost smooth. Under the higher powers of the microscope the shell is seen to be minutely punctate, and enough spinules are present on the costellae to give a vague radial appearance. Few specimens, however, retain the original test, and the casts show no surficial details. Specimens with the actual shell are iridescent, probably because of minute fractures.

Measurements: The holotype is 4.00 mm. long and 3.00 mm. high. Many smaller specimens are present in the collection, but none larger. Costellae about 40.

Comparisons: This is probably the species which Jones[1] identified as *Estheria minuta* (Alberti) from specimens which Prosser collected from the red beds of the Permian Cimarron series in Kansas. Beede[2] used the same name, but conservatively as *Estheria? minuta* Jones?, and Snider[3] more recently cited Jones' tentative identification of the species. But as Jones himself pointed out, all sorts of specimens have been identified as *Estheria minuta*. Any small "Estheria" from the Triassic is so identified, and apparently any red beds above the coal have been suspected of being Triassic.

Formation and locality: The holotype, M.C.Z. no. 4781, is from the Wellington formation, Lower Permian, at a locality in the SW ¼ of NW ¼, Sec. 2, T 21 N, R1W, Noble County, Oklahoma. The species occurs at many localities and at various horizons over an area of about 400 square miles in this general region. It is extraordinarily abundant. On one slab there are 113 specimens on 9 square inches, varying from 6 to 23 per square inch. If this is a fair sample, there would be 50,263,-155,400 individuals in a square mile and something over 20 trillion in the whole area. This is an estimate based on one layer at one locality, and is probably high, but if all the layers containing the species were taken into account, it is likely that an even larger figure would be reached. Why not use these shells for wampum, and pay off the national debt with *Lioestheria raaschi*?

Lioestheria inornata spec. nov.

Estheria ovata Jones (partim, nec Lea), Palaeontog. Soc., London, 1863, p. 84, pl. 2, figs. 28–31 (not figs. 26, 27, 32–38).

The extremely numerous thread-like, somewhat irregular costellae of this shell show that it is a Lioestheria, perhaps the youngest representative of the genus. According to Jones, the holotype (shown in his figure 28) is 8 mm. long and 6 mm. high, the greatest height being at about the middle of the valve. The intervales are smooth and punctate.

The specimens are from the Upper Triassic at Harding's pit, near Richmond, Virginia. The holotype is in the British Museum (Natural History).

Erisopsis gen. nov.

Lioestheriidae with sub-triangular carapace, the axis of the shell oblique, producing a pelecypod-like form. Genotype, *Erisopsis belli* sp. nov.

[1] Geol. Mag. dec. 4, vol. 5, 1898, p. 292, figs. 1–4. Fig. 3 is the only one which represents a Lioestheria.
[2] Kansas, Univ. Sci. Bull., vol. 4, 1907, p. 146.
[3] Oklahoma Geol. Sur., Bull. **11**, 1913, p. 108.

Shells of this sort closely resemble pelecypods and could easily be mistaken for them in cases where the chitinous material is not preserved. The type-species has rather widely spaced lirae, but *E. tessellata* (Jones) has the surficial markings of a Lioestheria.

Erisopsis belli spec. nov.

Plate 1, fig. 6

Carapace obliquely sub-oval, mytili-form, the greatest height back of the center. Beak near the anterior end, hinge straight. Surface with 16 narrow raised lirae, with broad interspaces.

The outline of this shell, with its axis directed from the beak to the ventral posterior end, strongly suggests reference to Palaeolimnadiopsis, but the lirae are not reflexed. Possibly it is an ancestor of the Palaeolimnadiopsis group.

Measurements: Length about 5.00 mm., height, 3.75 mm.

Horizon and locality: From the Cheverie formation, below the Windsor, on shore southwest of Cheverie on the Avon River, opposite Horton Bluff, Nova Scotia. Holotype in the Victoria Memorial Museum, Ottawa, Ontario. Collected and loaned by Dr. Walter A. Bell, for whom it is named.

Erisopsis tessellata (Jones)

Plate 1, figs. 7–9

Estheria tessellatus Jones, Trans. Geol. Soc. Glasgow, vol. 9, 1891, p. 80, pl. 5, figs. 2, 3, 4a, 4b.

This species has a short hinge (length 4.00 mm.) whereas the length of the carapace, measured along the diagonal axis, is 7.00 mm. The surface shows numerous closely-spaced lirae with minute quadrate pits in the spaces between them. The specimens were on the surface of a cannel coal, supposed to have come from the Upper Coal Measures of Ayrshire, Scotland.

Erisopsis adamsii (Jones)

Estheria adamsii Jones, Geol. Mag. vol. 7, 1870, p. 217, pl. 9, figs. 1a–c, ? 2.

The straight hinge, oblique axis, and the delicate reticulation of the valves make this an outstanding branchiopod. The length, more than an inch, is unusual. The resemblance to a pelecypod is so remarkable as to make one somewhat suspicious. The specimens were from the Coal Measures of Wales.

Asmussia Pacht

Asmussia Raimund Pacht, Der Devonische Kalk in Livland, 1849, p. 44. (A master's thesis, Dorpat. There is a copy in the Museum of Comparative Zoölogy.)

Posidonomya Pacht, Ueber Dimerocrinites oligoptilus, 1852, p. 26;—Der Devonische Kalk in Livland, 2d ed., 1859, p. 44, fig. 7.

Estheria Jones, Quart. Jour. Geol. Soc., London, vol. 12, 1856, p. 376.

Euestheria Depéret and Mazeran, Soc. Hist. Nat. d'Autun, Bull. **25**, 1912, p. 172.

Asmussia membranacea Pacht, the genotype of this monotypic genus, has a straight hinge-line, a subcentral beak, concentric costellae, and reticulately sculptured intervales, a combination not found in any other estheroid. Pacht himself gave up his new genus, under the impression that the shells were those of pelecypods, but Jones showed, from the structure of the shell, that they were really crustaceans.

The authors of Euestheria mentioned it as belonging to their subgenus of Estheria, because of the reticulate ornamentation, but the straightness of the hinge and position of the beak are such important characteristics that it seems best to revive the old name Asmussia.

Asmussia membranacea Pacht

Plate 2, fig. 1

Asmussia membranacea Pacht, Der Devonische Kalk in Livland, 1849, p. 44.

Posidonomya membranacea Pacht, Der Devonische Kalk in Livland, 2d ed., 1859, p. 44, fig. 7.

Estheria membranacea Jones, Palaeontographical Soc. London, for 1862, (1863) p. 18, pl. 1, figs. 6–7 (non figs. 1–5). (For a fuller bibliography see this paper.)

Estheria membranacea Lutkevich, Bull. Com. Geol., Leningrad, vol. 48, 1929, pp. 718, 728, pl. 36, figs. 1, 2a, b, 3, 4.

Specimens identified as this species have been reported from the original locality in Livonia, from northern Scotland, the Orkney and Shetland Islands, and from the northern Catskills of New York. All show the important generic characteristics, but there is considerable difference in the details. For example, the specimens from Livonia have about 13 concentric lirae, those from Scotland 18 to 20 costellae, and those from New York more than 30. Since all are of about the same size, this results in considerable difference in appearance.

Since there are other differences in the proportion of length to height, and in the position of the beak, it seems best to recognize three

species, particularly since Jones has already given a name, (*Estheria murchisoniana*) to the Scotch specimens.

It is an interesting but futile speculation to try to account for the changes which took place during the travels of members of this genus. Did it originate in Livonia, and add increments to its shell because of more favorable conditions in western Europe and North America? Or did the reverse happen? More favorable conditions in Livonia may have caused growth to be more rapid, so that adult size was reached in a short time, hence with fewer additions at the margin. One could argue either way with no satisfactory answer.

Asmussia progrebovi (Lutkevich)

Estheria progrebovi Lutkevich, Bull. Com. Geol., Leningrad, vol. 48, 1929, pp. 719, 728, pl. 36, figs. 5, 5a, 6, 6a, 7, 7a, 8.

Estheria sinuata Lutkevich, Bull. Com. Geol., Leningrad, vol. 48, 1929, pp. 720, 728, pl. 36, figs. 9, 9a, 10, 10a, 11.

This is undoubtedly an Asmussia, differing from *A. membranacea* Pacht in its greater length. According to Lutkevich its age is Middle Devonian. *Estheria sinuata* is evidently founded on a pathologic specimen of *A. progrebovi*, with which it is associated. The reentrant in the anterio-ventral margin must have been due to some accident.

The locality is on the Ruia River, near its junction with the Pliusa, southwest of Wesenberg in Esthonia.

Asmussia murchisoniana (Jones)

Plate 2, fig. 2

Estheria murchisoniana Jones, Quart. Jour. Geol. Soc., London, 1859, vol. 15, p. 404, figs. 14, c, d, p. 408;—Palaeontog. Soc., 1863, p. 14, pl. 1, figs. 1–5.

Estheria membranacea Jones, Geol. Mag., dec. 3, vol. 7, 1890, pl. 12, figs. 9a, b.

From the Upper Devonian of northern Scotland, the Hebrides, and the Shetlands.

Asmussia clarkei spec. nov.

Plate 2, figs. 3, 4

Estheria membranacea Clarke (nec Pacht), Rept. New York State Paleontologist for 1900, 1902, app. 3, p. 103, pl. 4, figs. 1–4. (In Univ. of State of New York., State Museum Rept., vol. 54, no. 1, 1902.)

Clarke gave no real description of his specimens but did provide excellent illustrations. The outline is much as in the Scotch and Li-

vonian specimens, that is, rounded-sub-quadrate, the chief specific characteristic being the presence of numerous crowded costellae, at least double the number present in European specimens. The largest specimen figured, 5.75 mm. long and 4.5 mm. high, (Clarke's fig. 2) has approximately 26 costellae, whereas a smaller one (fig. 1) has 29.

Asmussia membranacea in Livonia has thin lirae, not rounded costellae, and they are widely separated. Apparently the highest number present is 15.

A. clarkei is perhaps more closely allied to the Scottish form, since the latter has costellae rather than lirae, but 20 is the highest number reported from any of these specimens.

Horizon and locality: This species has so far been reported only from the basal beds of a green shale which overlies the Sherburne sandstone in Felter's Glen, 2.8 miles southeast of Rensselaerville, New York. According to Dr. G. A. Cooper, the age is Mid-Devonian.

Orthothemos gen. nov.

Lioestheriidae with straight hinge, sub-central beak, numerous costellae or lirae, the intervales punctate. Genotype, *Estheria draperi* Jones and Woodward.

This genus is suggested for species which in many respects resemble Asmussia, but lack reticulations, the intervales being merely punctate. The range appears to be from the Permian to the Cretaceous, but the identification as Permian of the South American beds in which it occurs is somewhat doubtful.

Orthothemos draperi (Jones and Woodward)

Plate 2, fig. 5; 6

Estheria draperi Jones and Woodward, Geol. Mag. dec. 4, vol. 1, 1894, p. 289, pl. 9, figs. 1, 1c.

Estheria stowiana Jones and Woodward, Geol. Mag. dec. 4, vol. 1, 1894, p. 290, pl. 9, figs. 2a, 2b.

Cyzicus (*Euestheria*) *draperi* Haughton, Ann. So. African Mus., vol. 12, 1924, p. 326.

These fossils with straight hinges might be included in Asmussia, but they have much more numerous concentric lirae and no trace of reticulation, the intervales being punctate. From Pseudestheria they differ not only in the straight hinge, but in the sub-central position of the beak. They are from the Cave sandstone, Upper Karroo (Triassic) at localities in Cape Colony, South Africa.

Orthothemos regularis (Reed)

Estheria regularis Reed, Bol. 34, Serv. Geol. e Min. do Brasil, 1929, p. 2, pl. 1, figs. 1–5.

This species is similar to the South African type of the genus, but the hinge is relatively shorter, the anterior and posterior ends decidedly rounded. The concentric lirae are also fewer in number. It is presumably from the Permian (or Triassic?) at a locality on the River Ignassu at Vallões, Brazil.

Orthothemos multistriatus (Reed)

Estheria regularis multistriata Reed, Bol. 34, Serv. Geol. e Min. do Brasil, 1929, pp. 4, 5, pl. 1, figs. 6, 7.

This form, described as a variety by Reed, has more numerous concentric lirae than *O. regularis*. Permian?, Brazil. Locality the same as the previous species.

Orthothemos neotropicus (Reed)

Estheria neotropica Reed, Bol. 34, Serv. Geol. e Mineral do Brasil, 1929, pp. 4, 5, pl. 1, fig. 8.

So far as one can determine from the description and illustration, this species is much like *O. regularis*, but is said to have "closely placed regular equidistant delicate raised transverse lines" on the surface. Permian?, Brazil. Locality the same as the preceding.

Orthothemos ovalis spec. nov.

Estheria amurensis Chernyshev, (*partim*), Geol. and Prospecting Service, U.S.S.R., Bull. **49**, no. 10, 1930, pl. 1, fig. 4.

The beak is almost central and the costellae are numerous, probably about 20, so far as one can tell from the photograph. It is from the Upper Cretaceous on the Amur River in Siberia.

Euestheria Depéret and Mazeran

Euestheria Depéret and Mazeran, Soc. d'Hist. Nat. d'Autun, Bull. 25, 1912, p. 169, pl. 5, figs. 2, 3, 4.

Lioestheriidae of oval form, anterior beak, distinctly separated costellae, with a pattern of minute polygons in the intervales. Genotype, (here selected) *Posidonia mintua* von Zieten. Depéret and Maze-

ran did not designate a genotype, but their discussion was based primarily on this species.

Most of the forms with this pattern in the furrows between the costellae seem to be Triassic in age. It is necessary to have well preserved specimens to see the polygons, and a source of error is present, for many internal casts show a similar pattern, due to the presence of small sand grains. The cement between them often presents a polygonal design. Many of the Devonian specimens belonging to various genera show this, as can be seen by consulting the figures in Jones' Monograph (1863).

Euestheria minuta (von Zieten)

Plate 2, figs. 7, 8

Posidonia minuta Alberti, (*Nomen nudum*), in De la Beche, Handbuch der Geologie, translated by H. von Dechen, Berlin, 1832, p. 453.

Posidonia minuta Goldfuss, Alberti, (*nomen nudum*), Jahrb. für Min., 1832, p. 227. Mentioned by Alberti, but species ascribed to Goldfuss.

Posidonia minuta von Zieten, Die Versteinerungen Württembergs, 1833, p, 453, pl. 54, fig. 5. Ascribed to Alberti. No description, but a specimen figured.

Posidonia minuta Alberti, Beit. zu einer Monographie des Bunten Sandst., Muschelk., und Keup., 1834, p. 120. Species ascribed to Goldfuss. A description given, with reference to von Zieten's figure.

Posidonia minuta Goldfuss, Petrefacta Germaniae, Zweiter Theil, 1840, p. 118, pl. 113, fig. 5. Gives a description and claims the species for himself.

Estheria minuta Jones. Paleontog. Soc., London, 1863, pp. 42–66, pl. 1. figs. 28–30, pl. 2, figs. 1–7, pl. 5, figs. 8, 9. Ascribes the species to Alberti and gives a full history and bibliography;—Geol. Mag., dec. 3, vol. 7, 1890, p. 387, pl. 12, figs. 6, 7, (not figs. 5 or 8.); Gross, Senckenbergiana, vol. 16, 1934, pl. on p. 311, fig. 7.

I have been unable to determine the exact standing of the name *Estheria minuta*. It has been ascribed to both Alberti and Goldfuss, but the legal author is probably von Zieten. The earliest mention I have been able to find is in the Jahrbuch für Mineralogie, 1832, p. 227, in which it is not described, but listed as *Posidonia minuta* Goldfuss in a brief article signed by F. A. von Alberti. It is mentioned again in von Dechen's translation of De la Beche's Manual of Geology (1832, p. 453) but not described. In Friedrich von Alberti's "Monographie des Bunten Sandsteins, Muschelkalks, und Keuper, 1834, p. 120, is the following description:

"*Posidonia minuta* Goldfuss: queroval mit 9–10 concentrishen Rip-

pen. Grösse einer Linsie, ähnlich der *Posidonia Becheri* Bronn's aus dre Grauwacke, und der *Posidonia Bronni* Goldfuss des Lias, aber kleiner und zierlicher." This, so far as I can find, is the first description, but unfortunately in the previous year, C. H. von Zieten, in his "Die Versteinerungen Württembergs", p. 72, pl. 54, fig. 5, had published a figure, ascribing the species to Alberti. Even though he gave no description, the issuing of the name with a recognizable figure would constitute legal publication. Hence the proper designation appears to be *Euestheria minuta* (von Zieten) rather than Goldfuss or Alberti.

This matter of names is brought up, not because it has any particular importance at the moment, but as an illustration of the exasperating problems which the present writer has constantly encountered in trying to describe a few Oklahoman fossils. The lioestherians from the American Permian which have been identified as *Estheria minuta* are like the original Triassic specimens in size only.

In spite of dubious taxonomic history of *E. minuta*, there has never been much doubt about the shells to which the early writers gave the name. The carapace is small, with from 8 to 12 low costellae, separated by furrows with about the same width. In these intervales are the polygons which are characteristic of the genus. The species is common in the Upper Triassic of Germany, France, and Great Britain.

Euestheria? stockmansi Maillieux

Estheria (*Euestheria*) *stockmansi* Maillieux, Mus. Royal d'Hist. Nat. Belgique, Bull. **15**, 1939, No. 10, p. 4, text-figs. 1 a, b, 2.

This species has a few prominent lirae and much resembles *Pseudestheria dawsoni* Jones. Maillieux says, however, that the intervales show a distinct reticulation, to be seen at a magnification of 50 diameters. It is from the Lower Devonian of the Ardennes of Belgium. An interesting feature is the presence of Spirorbis in the same beds.

The author shows no illustration of the reticulations, and one wonders whether they are real, or whether the appearance is due to the clastic grains in the shale in which they are imbedded. An allocation to Pseudestheria would seem more reasonable than one to the Triassic Euestheria.

Euestheria autunensis spec. nov.

Plate 2, fig. 11

Estheria minuta Depéret and Mazeran, (*nec* von Zieten), Soc. Hist. Nat. d'Autun, Bull. **25**, 1912, p. 169, pl. 5, figs. 2–4.

This species, according to its authors, is represented by numerous specimens, but the preservation is "mauvais, écrassés et laminés". They state that the number of costellae is "quinzaine," but they are more numerous on individuals from 3 to 5 mm. in length. Twenty to twenty-five can be counted on some of those illustrated by their photographs, a far greater number than those on the true *Euestheria minuta*. But in French *quinzaine* means "fifteen, more or less". There is even a question whether the species answers to their description of their subgenus Euestheria, for they state that only "Certains echantillons, mieux conservés que les autres, permettent de distinguer confusément, au microscope, une ornamentation réticulée, polygonale, dans l'intervalle des cordons". This is evidence that their genus was really founded on the Rhaetic *Estheria minuta*.

This species is found in the Middle and Upper Permian in the Autun coal basin of Northeastern France.

Euestheria exigua (Eichwald)

Posidomya minuta Kutorga, (*nec* Bronn), Verhand. Min. Gesell., St. Petersburg, 1844, p. 66, pl. 1, fig. 1–5.

Posidomya exigua Eichwald, Geogn. Russland, 1846, p. 455;—Lethaea Rossica, 1855, livr. 4, p. 231; Bull. Soc. Imp. Nat. Moscow, vol. 29, 1856, pt. 2, p. 559; Lethaea Rossica, 1859, livr. 6, p. 941, pl. 40, fig. 4.

Cyclas eos Eichwald, Geogn. Russland, 1846, p. 466.

Cytherina (*Cyclas*) *eos* Eichwald, Bull. Soc. Imp. Nat. Moscow, vol. 30, 1857, pt. 2, p. 307.

Posidomya eos Eichwald, Lethaea Rossica, 1859, livr. 6, p. 942, pl. 37, p. 13.

Estheria exigua Jones, Palaeontog. Soc., London, vol. for 1862, (1863), p. 37, pl. 1, figs. 22–24.

The above citations are from Jones. The present writer has no opinion on the identification of these fossils. The examples figured by Jones are euestherias. Whether or not they are the true *E. exigua* of Eichwald is left for Russian students to determine. Jones has pointed out the difficulties.

The original specimens were found in the Permian of Russia.

Euestheria mangaliensis (Jones)

Estheria mangaliensis Jones, Palaeontog. Soc., London, 1863, p. 48, pl. 2, figs. 16–23;—Geinitz (*partim*), Palaeontographica, suppl. vol. 3, Palaeont. Theil 2, Abth. 2, 1876, p. 3, pl. 1, figs. 4 and 7, 1, 2;—Middleton, Intellect. Observer. No. 21, 1862, p. 317;—Jones, Geol. Mag., dec. 2, vol. 5, 1878, p. 102;—Medlicott and Blanford, Manual Geol. India, 1879, p. 130, text fig.; 2d. ed., 1893, p. 170, text fig.; Jones, Geol. Mag., dec. 4, vol. 4, 1897, p. 261.

This species has about 15 regularly spaced lirae, with additional closely crowded ones near the ventral margin. The intervales appear to be punctate, but there is an obscure reticulation. It is not possible, without specimens, to say definitely whether it is a Pseudestheria or an Euestheria. It is found in the Triassic of central India, and according to Geinitz, in the Rhaetic of Argentina.

Euestheria laxitecta (Jones)

Estheria laxitecta Sandberger (nomen nudum), Verhandl. d. K. K. Geol. Reichsantalt, No. 16, 1871, p. 323;—Jones, Geol. Mag., dec. 2, vol. 5, 1878, p. 102.

Estheria minuta Alberti, =*E. laxitecta* Sandberger, Jones, Geol. Mag., dec. 3, vol. 7, 1890, p. 387, pl. 12, figs. 5, 8 a, b.

Jones considered this to be *Estheria minuta*, but since Sandberger did not describe or figure it, Jones becomes, although inadvertently, the author of the species. It differs from *E. minuta* in being larger and in having much more numerous lirae. The sculpture is typically euestherian. It is from the Lower Keuper at Windsheim, central Franconia.

Euestheria brodieana (Jones)

Estheria minuta var. *brodieana* Jones, Palaeontog. Soc., London, vol. for 1862, 1863, p. 66, pl. 2, figs. 8–15; Geol. Mag., dec. 2, vol. 5, 1878, p. 102.—Roemer, Zeitsch. d. geol. Ges., vol. 15, 1863, p. 702; Geologie von Obernschlesien, 1870, p. 176, pl. 15, figs. 10, 11.

This species differs from *E. minuta* in having smaller polygons in the intervales. It is found in the Upper Triassic (Rhaetic) of England, Scotland, and Germany.

Euestheria forbesii (Jones)

Estheria forbesii Jones, Palaeontog. Soc., London, 1863, p. 109, pl. 4, figs. 8–11; Geol. Mag. dec. 4, vol. 4, 1897, p. 263, pl. 11, figs. 1 a, b, 2.

E? *mendocina* Philippi, Tert. u. Quart. Verst. Chiles, 1887, p. 223, pl. 50, fig. 12.

E. mangaliensis (*partim*) Geinitz, Beitiäge zur Geol. u. Pal. des Argentinischen Republik, vol. 2, Palaeont. Theil, Abth. 2, 1876, p. 3, pl. 1, fig. 5.

This species has the typical form and reticulate ornamentation of Euestheria. It was collected in considerable numbers at Cacheuta,

south of Mendoza, Argentina. At the time Jones described it, the horizon was unknown, but the probabilities are that it is Triassic in age.

Pseudestheria gen. nov.

Lioestheriidae with oval carapace, engirdled by concentric lirae or costellae separated by spaces equal to or greater than their own width. No sculpture, except punctation, is present in the intervales. Genotype, *Pseudestheria brevis* sp. nov.

Since Estheria is a fly, it is not good practice to name a crustacean in such a way as to mislead entomologists. But in deference to paleontologists, who will regret, and perhaps protest, the passing of the name Estheria from our literature, I am venturing to use various combinations in which that word appears. The "false" portion of this one should be a warning to the dipterologists. I should have avoided such a practice were it not for the fact the "Estheria" looms large on the horizon of the paleontologist, whereas Estheria is just an unimportant fly, lacking even a nuisance value.

Pseudestheria and Euestheria are much alike, the difference being entirely in the sculpture. Since the polygonal pattern of the latter can be seen only on the best-preserved specimens, and even then only under the higher powers of the microscope, it is impossible in many cases to make definite identifications. Pseudestheria must inevitably become a sort of dumping ground for not-too-well preserved fossils. This is unfortunate, for it means that the genus has no stratigraphic significance. It may be possible, at some later date, to make a distinction between Pseudestheria *vera* and Pseudestheria *senso lato*. Used in its wider sense, the genus appears to range from the Lower Devonian to the end of the Triassic.

Pseudestheria brevis spec. nov.

Plate 2, figs. 9, 10

Carapace ovate, the beak near the anterior end. The height is to the length as about 7:10, and there are about 15 costellae, which are coarser and farther apart in the middle of the valve than in the ventral region. Casts of the interior are almost smooth, with widely spaced pseudostriae.

The holotype, M.C.Z. No. 4798, is 5.50 mm. long and 3.50 mm. high.

Formation and locality: SW ¼, NW ¼, Sec. 2, T 21N, R1W, Noble County, Oklahoma. Wellington formation, Lower Permian. A few specimens have been found in other localities in Noble County. Collected by F. M. Carpenter and G. O. Raasch.

A pathologic individual (M.C.Z. 4805) may ultimately prove to be of some interest, for it has two radial carinae.

Pseudestheria diensti (Gross)

Estheria diensti Gross (*partim*), Senckenbergiana, vol. 16, 1934, p. 309, pl. on p. 311, figs. 1, 3, 4, 5. (non figs. 2, 6), ? 8, 9.

As so commonly occurs with the description of "Estherias", this species presents annoying problems. Study of the figures seems to show that three species, belonging to two genera, were described by Gross. Fortunately he designated the specimen shown in his figure 5 as the holotype. The shell is oval, with 15 to 18 lirae or narrow costellae. The describer states that there is a reticulate structure in the intervales, but his figures 8 and 9 are not convincing and he does not state which shells show them. The specimens are from the Lower Devonian of the Eifel district in Germany.

Pseudestheria subcircularis spec. nov.

Estheria diensti Gross (*partim*), Senckenbergiana, vol. 16, 1934, pl. on p. 311, fig. 6 (not figs. 1–5, 8, 9).

This is the subcircular specimen which Gross compared with *Paracyclas rugosa* Goldfuss. There appear to be 20 or more narrow lirae, with wide intervales. The outline is distinctive, and the beak subcentral. It is from the Lower Devonian of the Eifel district in Germany.

Pseudestheria plicata (Lutkevich)

Estheria plicata Lutkevich, Bull. Com. Geol. Leningrad, vol. 48, 1929, pp. 722, 729, pl. 36, figs. 15, 15 a, 16 a–d.

The coarse costellae, relatively few in number for the size of the carapace, indicate that this is a Pseudestheria. The specimens are from the Mid-Devonian, on the Ruia River, near Rojki village, in Esthonia.

Pseudestheria dawsoni (Jones)

Estheria sp. Dawson, Acadian Geology, p. 256, fig. 58 d.
Estheria dawsoni Jones, Geol. Mag. dec. 1, vol. 7, 1870, p. 220, pl. 7, fig. 15; *ibid.*, dec. 3, vol. 1, 1884, p. 361, pl. 12, fig. 12.
Not *Estheria dawsoni* of Jones, 1878, or Pruvost, 1919, or Chernyshev, 1928. (For these, see under Palaeolimnadiopsis).

Like everything else connected with this investigation, *"Estheria" dawsoni* presents a problem. Jones gave no real description of the species, but figured a specimen 4.6 mm. long and 2.8 mm. high, with a smooth umbonal region 2.0 mm. long and 0.8 mm. high. This was a specimen sent by Sir William Dawson himself, so should be authentic, but Jones specifically states that it is not well preserved. It is listed, both in Jones' article, and in the "Acadian Geology" as having been found in the "Lower Carboniferous at Horton." One would naturally suppose that Horton Bluff was the locality, but Dr. Walter A. Bell, who is more familiar with this portion of Nova Scotia than any other geologist, tells me that he has never found this species in the Horton Bluff formation. He has been good enough to send me his material from the Cheverie formation below the Windsor. Some of the specimens were collected on the shore southwest of Cheverie, on the opposite side of the Avon river from Horton Bluff, and it is probable that this is Dawson's locality. At any rate, Bell's specimens are much more like that figured by Dawson than like the one Jones illustrated. It seems likely that the individual in Jones' hands was defective, for concentric lirae are present close to the beak in the material Bell collected, and there is no such extensive smooth umbonal region as is shown in Jones' figure. This is important, for a large smooth umbo is characteristic of the Limnadiidae, whereas the specimens in the present collection are definitely Lioestheriidae. Two obviously different species are present in Bell's collection. The ones which seem to be *P. dawsoni* may be described as follows:

Carapace elongate oval, with from 6 to 15 sharply elevated concentric lirae, separated by wide interspaces. The ratio of height to length is about 2:3. Only one of the five specimens is really well preserved. It is 3 mm. long and 2 mm. high, and has 8 lirae. A specimen 4 mm. long has 12, and a larger, but poorly preserved individual appears to have about 15.

PSEUDESTHERIA ALTA spec. nov.

Fig. 1. *Pseudestheria alta* Raymond. The holotype. x 6.

Carapace short, nearly as high as long. Beak anterior, almost at the front, hinge straight. The anterior outline is gently convex, the ventral one boldly rounded. There are about 14 narrow lirae, those at the beak obscured by pressure.

The holotype is 4.00 mm. long and 3.90 mm. high. It differs from all other members of the genus in being so nearly equidimensional.

The only known specimen was collected by Dr. Walter A. Bell from the Cheverie formation, Mississippian, at his locality 2217 on the shore of the Avon River opposite Horton Bluff, Nova Scotia. It is in the Museum of the Geological Survey of Canada.

PSEUDESTHERIA LEAIAFORMIS spec. nov.

Fig. 2. *Pseudestheria leaiaformis* Raymond. The holotype. The radial carinae are scarcely visible on the specimen. x 6.

Carapace small, subrectangular, the ventral outline only slightly convex. There is a median depression, as in Leaia, but no distinct carinae. The type has about 10 or 11 concentric lirae, whose course is almost straight on the median portion of the shell.

The most striking features of this shell are the median depression and the course of the lirae. The median depression alone might be due to an accident of compression, but the lirae have a leaiaform appearance.

The holotype is 4.25 mm. long and 2.75 mm. high. A larger specimen is 6. mm. long, 4. mm. high, and has 11 or 12 lirae.

Three specimens were collected by Dr. Walter A. Bell from the Cheverie formation, Mississippian, on the shore of the Avon River opposite Horton Bluffs, Nova Scotia, and are in the Victoria Memorial Museum at Ottawa.

Pseudestheria youngi (Jones)

Estheria youngi Jones. Trans. Geol. Soc. Glasgow, vol. 9, 1891, p. 80, pl. 5, figs. 1 a, b.

If the figure were to be trusted, this species should be referred to the genus Palaeolimnadia, for it seems to have a large smooth umbonal area. But Jones says "Below the umbo, which is bare, having been damaged", which puts the specimen in the same class with his example of *Pseudestheria dawsoni*. If a well preserved specimen were to be had, it would, as is the case with *P. dawsoni*, probably show growth-lines in the umbonal region. In fact, it seems to be closely allied to *P. dawsoni*, having 10 lirae below the damaged umbonal region.

The specimens were found in a shale in the upper part of the Lower Carboniferous limestone near Thornliebank, four miles southwest from Glasgow, Scotland.

Pseudestheria peachi (Jones)

Estheria peachi Jones, Geol. Mag., vol. 7, 1870, p. 220, pl. 9, fig. 17.

The specimens are poorly preserved, poorly described, and the figure is open to question. So nearly as one can judge, the species is related to *P. dawsoni* (Jones). It was found in the Lower Carboniferous shales at Salisbury Craigs, Edinburgh, Scotland.

Pseudestheria blackstonensis spec. nov.

Plate 3, fig. 1.

Carapace subcircular, but with the greatest length at an angle oblique to the hinge. Surface apparently without markings other than rather equally spaced, slender concentric lirae, of which there seem to be ten. Umbonal region smooth, either from lack of lirae or because of the state of preservation. Length 7.00 mm., height, 6.25 mm.

The holotype (M.C.Z. 4800) was collected by W. P. Haynes from Mid-Pennsylvania strata on the south bank of the Blackstone River at Central Falls, near Pawtucket, Rhode Island.

Pseudestheria elongata (Chernyshev)

Estheria (*Euestheria*) *elongata* Chernyshev, Annuaire de la Soc. Paleontologique de Russie, vol. 6, 1926, p. 65, pl. 7, fig. 6.

This species from the Westphalian of the Donetz coal basin is similar to *P. simoni* (Pruvost), but more elongate.

Pseudestheria cebennensis (Grand 'Eury)

Estheria cebennensis Grand 'Eury, Geol. et Paleont. du Terrain Houiller du Gard., 1890, pp. 338, 339, pl. 22, fig. 4.

Estheria (*Euestheria*) *cebennensis* Chernyshev, Annuaire de la Soc. Paleontologique de Russie, vol. 6, 1926, p. 70, pl. 7, figs. 7–9.

This is a large oval form, with the beak a little further back than in *P. elongata* (Chernyshev). It has been found both in France and the Donetz basin of Russia.

Pseudestheria simoni (Pruvost)

Estheria tenella Jones (*nec* Bronn), Paleontog. Soc., London, 1863, p. 31 et seq. (*partim*), pl. 2, fig. 39, pl. 5, figs. 1–5, 7; Bolton, Quart. Journ. Geol. Soc., London, 1911, vol. 67, pl. 28, figs. 1, 2; Barrois, Cat. foss. Mus. Houiller, Lille, 1919.

Estheria simoni Pruvost, Ann. Soc. Geol. du Nord, vol. 40, 1911, p. 64, pl. 1, figs. 4–8, text-fig. 2; Terrain Houiller du Nord et du Pas-de-Calais, 1919, p. 57, pl. 24, figs. 29–33, text fig. 15;—Chernyshev, Annuaire de la Soc. Paleontologique de Russie, vol. 6, 1926, pp. 67–82.

The most striking feature of this species is the subcircular form of some of the specimens. *P. simoni* differs from *P. brevis* in the same way that it does from *P. tenella*, that is, it is larger and has more lirae. It is found in the Westphalian of England, France, and Russia.

Pseudestheria limbata (Goldenberg)

Estheria limbata Goldenberg, Fauna Saraep. Foss, pt. 2, 1877, p. 43, pl. 2, figs. 12–14;—Pruvost, 13th International Geol. Cong., Belge, 1922, p. 649;—Guthörl, Abhandl. der Preuss. Geol. Landesanstalt, vol. 164, 1934, p. 13, text-fig. 4, pl. 1, figs. 5, 6, pl. 2, fig. 1;—Waterlot, Bassin Houiller de la Sarre et de la Lorraine, pt. 2, Faune Fossile, Lille, 1934, p. 42, text-fig. 5 A, pl. 6, figs. 13, 13 a, b.

This species is similar to *E. tenella*, with which it has been repeatedly confused, but has more numerous concentric costellae. It is from the Stephanian of Saarbrücken.

Pseudestheria rimosa (Goldenberg)

Estheria rimosa Goldenberg, Fauna Saraep. Foss., pt. 2, 1877, p. 44, pl. 2, figs. 16–18.

Estheria limbata Leppla, Geol. Skisse d. Saarb. Steinkohleng., 1904, p. 36, figs. 6–9;—Pruvost, 13th International Geol. Congress, Belge, 1922, p. 649;—Waterlot, Bassin Houiller de la Sarre et de la Lorraine, pt. 2, Fauna Fossile, Lille, 1934, p. 42, text-figs. 5, B. C. pl. 6, figs. 14, 15, 15 a.

Estheria rimosa Guthörl, Abhandl. der Preuss. Geol. Landesanstalt, vol. 164, 1934, p. 14, text-fig. 5, pl. 2, fig. 2.

Pruvost and Waterlot agree that *P. rimosa* is only a form of *P. limbata*, with which it is associated. Since the present writer does not use varietal names, he has listed the references separately.

Pseudestheria molesta spec. nov.

Estheria chilensis Jones (*nec* Philippi), Geol. Mag., dec. 4, vol. 4, 1897, p. 289, pl. 10, fig. 4 (non fig. 5).

"Valves subcircular, approaching subquadrate, . . . Umbo at the antero-dorsal corner, and at an angle of 40° to the extreme curvature of the concentric ringlets. Hinge-line straight behind the umbo, about half the length of the longest diameter of the valve. The other edges rounded; the anterior nearly semi-circular; the ventral obliquely curving up to meet the steeper and narrower posterior curve."

The specimen is from strata of unknown age, perhaps Carboniferous, from Arica, Peru.

Pseudestheria plicifera spec. nov.

Plate 2, fig. 12

Valves small, with numerous costellae, between which are narrow intervales. It differs from *P. brevis* in the more numerous concentric markings. The holotype is 5.00 mm. long and 3.75 mm. high. It has about 17 costellae.

Formation and locality: The holotype, M.C.Z. No. 4791, is from the Wellington formation, Lower Permian, at a locality in SE ¼, NE ¼, Sec. 34, T 22 N. R1W, Noble County, Oklahoma. It is a rather rare species but has been found by Carpenter and Raasch at other localities in the same region. Dr. Carpenter found three specimens in the famous insect-bearing beds of the Wellington at Elmo, Kansas.

Pseudestheria rugosa spec. nov.

Plate 3, fig. 2

Carapace short and high, with conspicuous costellae which are somewhat irregularly developed on the holotype. The length is 7.00 mm., the height 6.00 mm., and there are about 18 costellae. The single individual known is probably pathologic because of an injury during mid-life, but it has characteristics which show that it is not an abnormal individual of any of the associated species.

It differs from *Pseudestheria plicifera* in being higher in proportion to the length and in having coarser costellae, and from *P. brevis* in having coarser concentric markings.

The specimen, (M.C.Z. 4806) was collected by Drs. Carpenter and Raasch from the Wellington formation (Lower Permian) in the S W corner, Sec. 28, T 23 N. R1W, 10 miles north of Perry, Noble County, Oklahoma.

Pseudestheria tenella (Bronn)

Posidomya tenella Bronn, Neues Jahrb. für Min., 1850, pp. 577–579.

Estheria tenella Jones (*partim*), Palaeontog. Soc., London, 1863, p. 31 et seq., pl. 5, fig. 6, ? pl. 1, figs. 26, 27, (not pl. 2, fig. 39, pl. 5, figs. 1–5, 7).

Estheria tenella Goldenberg, Fauna Saraep. Foss., pt. 1, 1875, p. 23, pl. 1. fig. 25 b; *ibid.*, pt. 2, 1877, pp. 42, 52, pl. 2, figs. 9–11;—Pruvost, Terrain Houiller du Nord et du Pas-de-Calais, 1919, p. 58, footnote 2, p. 59.

Estheria tenella Guthörl, Abhandl. der Preuss. Geol. Landesanstalt, n. f., vol. 164, 1934, p. 12, text fig. 3, pl. 1, figs. 3, 4.

Guthörl was the first to point out the obvious fact that Bronn was the actual describer of this species. Jones had listed it under two authors, first under Jordan, and then under Jordan and Bronn. Goldenberg in 1875 (Guthörl takes the date at its face-value, 1873) merely says *Estheria tenella* sp., but in 1877 he credits it to Jordan although he makes the usual erroneous citation of Jordan and Bronn. Pruvost again cites Jordan as the author, although he was the first to point out that the Lancashire forms identified by Jones as this German species were wrongly named.

Pruvost straightened out the situation to a certain extent, and suggested that the specimen from the Permian at Salzback figured by Jones, be accepted as the topotype. He also thought that the specimens from Oschatz, Saxony, figured by Jones (pl. 1, figs. 26, 27), might really belong to *E. tenella*.

Guthörl, however, searched the Jordan collection in the Natural History Museum in Berlin, and selected the specimen shown in his pl. 1, fig. 3, as the lectotype. Since this is from the original locality and in the collection which Bronn studied, it is doubtless an authentic specimen. It is, unfortunately, considerably crushed, and Guthörl's text-figure is obviously inaccurate. His fig. 4, pl. 1, undoubtedly gives a better idea of the species. The age is Lower Permian.

Pseudestheria geinitzii (Jones and Woodward)

Estheria geinitzii Jones and Woodward, Geol. Mag., dec. 3, vol. 10, 1893, p. 531, pl. 19, fig. 4.

The small, short, high carapace with about 10 growth lines suggest comparison of this species with *P. brevis* Raymond. It is from the Permian near Münster on the Nabe, Germany.

Pseudestheria grebeana (Jones and Woodward)

Estheria geinitzii var. *grebeana* Jones and Woodward, Geol. Mag., dec. 3, vol. 10, 1893, p. 532, pl. 19, fig. 5.

The carapace is similar to that of *P. geinitzii*, with which it is associated. The authors suggest that the difference is sexual, since one shell is subquadrate, the other sub-triangular. Permian, near Münster on the Nabe, Germany.

Pseudestheria drummi (Guthörl)

Estheria drummi Guthörl, Oberrheinischer Geol. Verein, Jahrsberichte, n. f., vol. 20, 1931, p. 80, pl. 1, fig. 4, text fig. 1; Abhandl. der. Preuss. Geol. Landsanstalt, vol. 164, 1934, p. 15, pl. 2, fig. 3, text fig. 6.

The description and figures of this species are so poor that it is practically unrecognizable. The text-figure suggests reference to the genus Orthothemos, but the photograph precludes such an assignment. The specimens are from the Lower Permian of the Lebach-Saar district in western Germany.

Pseudestheria obenaueri (Guthörl)

Estheria obenaueri Guthörl, Oberrheinischer Geol. Verein., Jahrsberichte, n. f., vol. 20, 1931, p. 82, pl. 1, fig. 5, text-fig. 2; Abhandl. der Preus. Geol. Landesanstalt, vol. 164, p. 16, pl. 2, fig. 4, text-fig. 7.

This was described as the largest known "Estheria" (length 16. mm., height 10. mm.). As in the case of *P. drummi*, the photographs seem to show that the species fits in the genus Pseudestheria.

The specimens were collected from the Lower Permian at Lebach-Saar, a famous coal basin in western Germany.

Pseudestheria lata (Mitchell)

Estheria lata Mitchell, Proc. Linn. Soc. of New South Wales, vol. 52, 1927, p. 110, pl. 3, figs. 8, 9.

A large form, length 7 mm., height 7 mm., from the Upper Permian at Merewether Beach near Newcastle, New South Wales.

Pseudestheria belmontensis (Mitchell)

Estheria belmontensis Mitchell, Proc. Linn. Soc. of New South Wales, vol. 52, 1927, p. 110, pl. 4, fig. 5.

This is a form in which the costellae die out on approaching the hinge in the region behind the beak, thus producing a narrow flattened area which Mitchell likened to a hinge plate. It is from the Upper Permian near Belmont, Northumberland Co., New South Wales.

Pseudestheria novacastrensis (Mitchell)

Estheria novacastrensis Mitchell, Trans. Linn. Soc. of New South Wales, vol. 52, 1927, p. 109, pl. 3, figs. 5, 6.

This seems to be a typical member of the genus, although of large size, the highest figures given by Mitchell being: length 9 mm., height, 6 mm. It is from the Upper Permian (Newcastle Coal Measures), at Merewether Beach, near Newcastle, New South Wales.

Pseudestheria trigonellaris (Mitchell)

Estheria trigonellaris Mitchell, Proc. Linn. Soc. of New South Wales, vol. 52, 1927, 109, pl. 4, fig. 6.

The features are typical of the genus, and since the specimen is a mold of the exterior, it is fairly certain that no reticulate sculpture is present.

From the Upper Permian at Merewether Beach, near Newcastle, New South Wales.

Pseudestheria? obliqua (Mitchell)

Estheria obliqua Mitchell, Trans. Linn. Soc. of New South Wales, vol. 52, 1927, p. 109, pl. 4, fig. 1.

This is a single poor specimen from the Upper Permian at Merewether Beach near Newcastle, New South Wales.

Pseudestheria frikiensis (Grabau)

Estheria frikiensis Grabau, Stratigraphy of China, vol. 1, 1924, p. 486. (Upper Permian, China.)

Pseudestheria multicostata (Emmons)

Posidonia multicostata Emmons, Geol. Rept., North Carolina, 1856, p. 323, fig. W 1, 2; American Geology, pt. 6, 1857, p. 134, fig. 103; Manual of Geology, 2nd ed. 1860, p. 191, fig. 166, 4.

Estheria ovata Jones (*partim*, *nec* Lea), Palaeontog. Soc., London, 1863, p. 86, text-fig. 6.

Since the type of this species is not now available, it may be that I have not correctly identified it. I have seen no specimens from the original locality in North Carolina, but one which J. B. Woodworth collected at Midlothian, Virginia, appears to have the characteristics shown in Emmons' figure. The species differs from *P. ovata* Lea in having a straighter hinge, lirae instead of costellae, and a greater length in proportion to the height. If this identification is correct, the species occurs in the Upper Triassic of both North Carolina and Virginia.

Pseudestheria emmonsi spec. nov.

Estheria ovata Jones (*partim*, *nec* Lea), Palaeontog. Soc., London, 1863, p. 84, pl. 2, figs. 26, 27, non figs. 28–38.

As Jones points out in his article in the Geological Magazine, dec. 3, vol. 7, 1890, p. 386, this form from Prince Edward, near Richmond, Virginia, differs from the other Triassic varieties in North America in having the lirae widely separated. The intervales are smooth, and in this respect are similar to what seem to be typical specimens of *Estheria ovata* Lea from Pennsylvania. The number of concentric lirae is, however, much less.

Holotype: the specimen shown in Jones' figure 27, in the British Museum (Natural History).

Pseudestheria ovata (Lea)

Posidonia ovata Lea, Proc. Acad. Nat. Sci., Philadelphia, vol. 8, 1856, p. 77.
Possibly *Estheria* ovata Jones (*partim*), Paleontog. Soc., London, 1863, p. 8, 4, 84, pl. 2, figs. 28–37.

Lea's material was collected at a tunnel near Phoenixville in Eastern Pennsylvania, and, so far as I can learn has never been figured. The Museum of Comparative Zoölogy has material from this locality, probably collected by W. B. Rogers.

Lea did not properly describe his species, merely saying that it was seven-twentieths of an inch in transverse diameter, and that it had numerous minute concentric costellae. He also mentioned that it differed from the specimens Sir Charles Lyell[1] had figured, but not named, from Richmond, Virginia. Jones had in his hands a large collection from Phoenixville but unfortunately did not figure any of them. He noticed that there were three forms present, one broadly ovate, one more narrow, and one smaller type with thickly crowded ridges. From a study of our specimens I am inclined to think that the last is the real *E. ovata*. In many cases the shell is preserved and appears to be punctate. I can find no specimens with a definitely reticulate structure. It appears to be a Pseudestheria.

Pseudestheri hindei (Jones)

Estheria ovata Jones (*partim*), Palaeontog. Soc., London, 1863, p. 98.
Estheria hindei Jones, Geol. Mag., dec. 3, vol. 8, 1891, p. 51, pl. 2, figs. 5–8.

There are about 15 concentric costellae on a specimen 7 mm. long and 4.5 mm. high. The intervales are bare of ornament. It differs from *Pseudestheria ovata* (Lea) which occurs at the same locality in being proportionally longer. From the upper Triassic at Phoenixville, Penna.

Pseudestheria lewisii (Jones)

Estheria lewisii Jones, Geol. Mag., dec. 3, vol. 7, 1890, p. 385, pl. 12, figs. 3, 3 a.

There are 19 or 20 concentric lirae, relatively far apart on the dorsal region, closer together below. This feature, and the great length seem to characterize the species. The intervales show an irregular pattern which Jones ascribed to sand grains.

The specimens were from the Triassic sandstone of Bucks County, Pennsylvania.

[1] Quart. Jour. Geol. Soc. London, 1847, vol. 3, p. 274, fig. 6.

Pseudestheria? pennsylvanica (Wanner)

Estheria mangaliensis pennsylvanicus Wanner, Penn. Acad. Nat. Sci., vol. 78, 1926, p. 25, fig. 2.

Until specimens can be studied, it is futile to speculate about this form. It was poorly described and figured, and it seems possible that two species are involved, since the "number of ridges of growth" is said to be from 8 to 17. My feeling, from what I have seen of specimens, is that the number of conspicuous concentric ridges is not highly variable: the finer concentric markings on the margins may be ignored, for they are numerous in almost all species. This species, or variety, was described from specimens collected from the Upper Triassic of York County, Penna.

Pseudestheria ipsviciensis (Mitchell)

Estheria mangaliensis Etheridge (*nec* Jones), in Jack and Etheridge, Geol. and Pal. of Queensland and New Guinea, 1892, p. 387.

Estheria ipsviciensis Mitchell, Trans. Linn. Soc. of New South Wales, vol. 52, 1927, p. 107, pl. 3, figs. 1–4.

Ethridge's comparison of this form to *Estheria mangaliensis* would suggest reference to the genus Euestheria. Etheridge says "reticulation not preserved". Mitchell makes no comment on this subject but points out various ways in which the Indian and Australian species differ. The species is from the Upper Triassic at Denmark Hill, Ipswich, Queensland, Australia.

Pseudestheria heckeri (Chernyshev)

Estheria heckeri Chernyshev, Geol. and Prospecting Service, U.S.S.R., Bull. **49**, No. 10, 1930, pp. 73, 78, pl. 1, figs. 18–20.

Although the outline of the carapace is subcircular, the beak is anterior, and the intervales are punctate. There are from 5 to 7 concentric lirae per millimeter. The specimens came from Kubekova village on the Enissei River, Siberia, and the age is supposed to be Lower Jurassic or Upper Triassic (Rhaetic).

Pseudestheria ? faveolata (Chernyshev)

Estheria faveolata Chernyshev, Geol. and Prospecting Service, U.S.S.R., Bull. **49**, 1930, pp. 73, 78, pl. 1, fig. 17.

The generic reference is purely a guess. The description and figure provide no basis for anything more. The presence of "15 to 18 growth

ridges in 1 mm." suggests Lioestheria, but the species seems to be out of the usual vertical range of that genus. The specimens are from Khakharei, in Irkutsk, Siberia, and were derived from strata of Lower Jurassic or Upper Triassic (Rhaetic) age.

Psuedestheria ? kryshtofovichi (Chernyshev)

Estheria kryshtofovichi Chernyshev, Geol. and Prospecting Service, U.S.S.R., Bull. **49**, No. 10, 1930, pp. 75, 78, pl. 1, fig. 21.

This species is compared by its author with *Estheria faveolata*, but both are so poorly described and figured that one cannot be at all sure of the generic reference. The specimens are from Andreev's Bay, Ussuri Gulf, Siberia, and were found in strata whose age is not definitely determined ("approximates in age the Khakharei and Kubekova series").

Palaeestheria Barnard (emend)

Palaeestheria Daday de Deés, Ann. Sci. Nat. Zoology, ser. 9, vol. 20, 1915, p. 51. *Nomen nudum.* (No species mentioned.)

Palaeestheria Rennie, So. African Journ. Sci., Johannesburg, vol. 31, 1934, p. 233. *Nomen nudum.* (A poor specimen figured, but not named.)

Palaeestheria Barnard, Ann. So. African Mus., vol. 28, 1929, p. 254.

This genus has never been defined. Daday de Deés remarked that since Estheria must disappear from palaeozoölogy, he recommended the name Palaeestheria for all the fossils, and suggested the family name Palaeestheriidae. He named no particular species, and proposed no genotype. It was at that time an absolute *nomen nudum.*

Rennie described and figured a badly preserved specimen from the Witteberg series, (Devono-Carboniferous) at Port Alfred, Cape Colony, as Palaeestheria sp. The photographic illustration is as poor as the specimen, and Rennie was entirely right in not giving it a specific name, although he did give as good a description as was possible.

Barnard used the name in the same wide sense as Daday de Deés, and gave no diagnosis. He did, however, list three species under the generic name, which according to the rules would appear to make the genus valid. It therefore dates from Barnard and not from Daday de Deés.

I herewith select the first species listed by Barnard, *Estheria anomala* Jones, as the genotype and offer the following brief diagnosis, based on that species.

Carapace ovate, umbonal region smooth, the remainder bearing

numerous narrow, sharp costellae, between which there is no ornament.

This genus is in many respects similar to Pseudestheria, but differs in having more numerous and more close-set costellae, and particularly in having a larger smooth area at the umbo.

Palaeestheria anomala (Jones)

Plate 3, fig. 3

Estheria anomala Jones, Geol. Mag., dec. 4, vol. 8, 1901, p. 352, text-figs. 1–4.
Palaeestheria anomala Barnard, Ann. So. African Mus., vol. 28, 1929, p. 255.

"This left valve has the oblong-ovate shape common to the genus [Estheria] and bears evidence of numerous concentric close-set lines or ridges. It measures 5 mm. in length and 3 mm. in height."

Another specimen (Figs. 3, 4). "The spaces between the concentric ridges exhibit no ornament."

This description is brief, and so far as it goes, would not distinguish the genus from Pseudestheria. Inspection of the figures, however, shows that the umbo is relatively large and smooth.

The specimens are from shales associated with the Lower Cretaceous Enon conglomerate of the Uitenhage beds near Heidelberg, South Africa, a formation originally supposed to be Jurassic.

Palaeestheria ? andrewsii (Jones)

Estheria andrewsii Jones, Geol. Mag., dec. 3, vol. 8, 1891, p. 50, pl. 2, figs. 1–4.

This may be a Bairdestheria, but the large size of smooth umbonal shell suggest relationship to the Limnadiidae. Jones compares it with *E. subquadrata* and *E. elliptica*. The surface bears a delicate punctate sculpture which, on the casts of the interior, produces a "delicate linear granulation."

The specimens were found in the Wealdon (Perbeck) in Wiltshire, England.

Estheriella Weiss

Plate 3, figs. 4, 5

Estheriella Weiss, Zeit. Deutsch. Geol. Gesellschaft, vol. 27, 1875, p. 712 (first mentioned in footnote on p. 711);—Jones, Geol. Mag., n.s. dec. 3, vol. 8, 1891, p. 53, pl. 2;—Pruvost, Terrain Houiller du Nord et du Pas-de-Calais, 1919, p. 61.

This is one of the few generic names in common use, and the biblio-

graphy could be considerably extended. The above are, however, the really important papers.

Weiss based his subgenus of "Estheria" on the presence of radial ribs, which are largest and sharpest on the mid-ventral part of the carapace and become faint on the umbo and anterior and posterior ends. He ascribed two species, *Posidomya nodoso-costata* Giebel[1] and *P. wengensis* Giebel[2] (nec Wissmann[3]) to the new subgenus. Since the specific name *wengensis* was preoccupied in the genus Posidomya when Giebel used it, his species not being the same as that described by Wissmann, Jones in the article cited above has replaced it by *costata*, a term employed by Weiss in the footnote to his paper of 1875. Weiss gave no description, but stated that it was a name which he had expected to use until he became rather sure that his specimens really belonged to *Posidomya wengensis* Giebel.

Giebel's figures were poor, but Jones borrowed specimens from the type-locality, and published excellent figures of both species. Pruvost, in the memoir cited above, p. 61, casts doubt on the identification of the specimens figured by Jones as *Estheriella nodosocostata*, using for them the name *Estheriella lineata* Weiss. Weiss himself pointed out that Giebel's specimens had only 7 radial ribs, whereas the ones he studied had a maximum of 12. However, he stated that only those in the mid portion of the shell were prominent, and it may be that Giebel noticed these only. Since Jones', Weiss', and Giebel's specimens are from the same locality and since they agree in most features, it is probable that they belong to the same species. In any event, I propose to designate *Posidomya nodosocostata* Giebel the genotype of Estheriella.

In that case, the generic characteristics are the oval carapace with rather coarse radiating costae, separated by interspaces several times their own width. The radial costae die out as they approach the beak and the anterior and posterior ends. They are crossed by numerous rather widely spaced costellae, which produce nodes where they cross the radial costae.

The true *Posidomya wengensis* Wissmann has numerous radial costellae, so fine that they can be seen only under the microscope. It does not belong to this genus.

The largest specimen of *E. nodosocostata* has a length of 4.3 mm.,

[1] Zeitschrift für die gesamnten Naturwissenschaft, Halle, 1857, p. 309, pl. 2, fig. 7.

[2] *Ibid.*, p. 308, pl. 2, fig. 6.

[3] Beitrage zu Petrefacten-Kunde, Ausgeben von Graf von Munster, vol. 4, 1841, p. 23, pl. 16, fig. 12.

height 2.8 mm. The largest *E. costata* is 3.8 mm. long and 2.5 mm. high. The types are from the Bunter sandstone, Triassic, at Durrenberg, Sachsen, Germany.

Estheriella lualabensis Lariche

Plate 3, fig. 6

Estheriella lualabensis Lariche, Revue Zoologie Africaine, vol. 3, fasc. 1, 1913, p. 3, pl. 1, figs. 1–14, pl. 2, fig. 1. Brussels.

If Estheriella be restricted to those species which have the generic characteristics of *E. nodosocostata*, it is a small genus, and entirely confined to the Triassic.

It reaches its culmination in *E. lualabensis*, the most highly ornamented of all conchostracans. In the middle of the carapace there are five prominent radial costae, and strong nodes are formed where they are crossed by the concentric ribs. Less conspicuous radial markings are present on some specimens, so that the total number may be as many as 11. The radial markings die out on the umbo and near the ventral margin.

This species is common in the Triassic along the railroad between Stanleyville and Ponthierville, Belgian Congo, Africa.

Pruvost on Estheriella

Terrain Houiller du Nord et du Pas-de-Calais, 1919, p. 61.

Pruvost placed all conchostracans with radial markings in the genus Estheriella, but subdivided them into three groups.

1. Group of *Estheriella reumauxi* Pruvost. The members of this group have discontinuous radial markings, and what is more important, a sinuous posterior outline. The growth lines are reflexed at the dorsal border. This indicates that these species are allied to the modern Limnadopsis, and that they belong to the Limnadiidae, whereas the members of the second and third groups probably belong to other families. A new generic name will be proposed for this group on a later page.

Pruvost placed in this group *Estheriella trapezoidalis* Krotow, *E. oblonga* Krotow, and *E. costata* Weiss, but none of these species shows the generic characteristics of the type of *E. reumauxi*. They will be mentioned below.

2. Group of *Estheriella nodosocostata* Weiss (sic). This is the true Estheriella as restricted, and has already been discussed.

3. Group of *Estheriella multiradiata* (sic) Jones. Pruvost proposed to gather in this group species which were rounded-oval with concentric undulations rather than costae. These are crossed by numerous radial lirae. The umbo is subcentral in some; in others near the anterior end.

Jones described the species to which Pruvost refers as *Esheriella radiata* var. *multilineata*. Pruvost's citation is probably a *lapsus calami*. For this group I suggest the generic name Dadaydedeesia, in memory of that most proficient student of modern Conchostraca. The several other genera which have been named for him have used all the shorter variants.

Dadaydedeesia gen. nov.

Lioestheriidae with the carapace oval, subquadrate, or trapezoidal, but with rounded anterior ventral and posterior outlines. Surface with concentric undulations, costellae, or lirae, crossed by radiating lirae which may be continuous over the whole shell or present on certain portions only. Beak sub-central to sub-anterior in position. Genotype, *Estheriella multilineata* Jones.

This genus is probably artificial, and could easily be split into several genera, but the time does not seem ripe for doing so. The previous position of students of this type of conchostracan has been that all species with radial markings were closely related. Now that further study has shown that two families are involved, it becomes fairly certain that radial markings were developed in various lineages. Dadaydedeesia is therefore likely to be broken up later, when more is known about the fossils.

Dadaydedeesia multilineata (Jones)

Plate 3, figs. 9, 10

Estheriella radiata (Salinas) var. *multilineata* Jones, Geol. Mag., dec. 5, vol. 2, 1905, p. 50, pl. 2, figs. 1–4.

"The valves are broadly subovate, nearly semicircular, short, and broad or oval-oblong with rounded ends. The anterior extremity has the bolder curvature. The dorsal border is nearly straight; ventral border boldly curved. The umbo is toward the anterior end of the dorsal border, at one-third the length of the valve. . . . The main concentrics or wrinkles are about fifteen in number . . . having numerous small, subsidiary, parallel raised lines intercalated on their surfaces and in their interspaces, . . . crossed with a radial ornament.

"The Malayan specimens are characterized by having twenty-four and more delicate, close-set, parallel linear furrows radiating from the umbo to the ventral edge of the valve."

The specimens are from the Triassic at Pukus Semanggol, Larut, Perak, Malay Peninsula.

Another species which seems to be related and referable to this genus is *Estheria tegulata* Jones [1] from the Coal Measures of Scotland. *Estheria radiata* Salinas[2] from the Triassic of Sicily, is, according to Jones, even more closely related. Pruvost also included *Estheriella lualabensis* in this group, but as shown above, it seems to be a real Estheriella. I should include here three species which Pruvost assigned to his group of *Estheriella reumauxi*. These are *Estheriella trapezoidalis* Kratow,[3] from the Permocarboniferous of Russia, *Estheriella oblonga* Kratow[4] from the same locality, and *Estheriella costata* Weiss[5] from the Triassic of Dürrenberg, Saxony. All of these species differ from *E. reumauxi* in lacking the backward curve of the growth-lines at the hinge.

Dadaydedeesia ? aricensis (Jones)

Estheria aricensis Jones, Geol. Mag., dec. 4, vol. 4, 1897, p. 264, pl. 10, figs. 1–3.

The state of preservation of the specimens, as described by Jones, makes it impossible to assign this species definitely to the genus under which it is here listed, but one individual shows interrupted radial lines. The specimens are rather large, ranging from 9.4 mm. to 17.0 mm. in length. They are from beds of unknown age, possibly Carboniferous, at Arica, Peru.

Monoleiolophus gen. nov.

Lioestheriidae with oval carapace, relatively widely spaced concentric lirae, and a single costa, extending from the beak to the posterior ventral margin. Genotype, *Monoleiolophus unicostatus* sp. nov.

This genus may be allied to Estheriella, or it may be that the single radial rib has no significance which can be interpreted at the present time. Since the genotype was found in a shale containing numerous

[1] Trans. Geol. Soc. Glasgow, vol. 9, (1891), p. 82, pl. 5, figs. 5, 6a, 6b.

[2] Sulle Esterie del Trias di Sicilia, small 8 vo. Palermo, Museo. Geol. Min. R. Univ. Palermo 1897, pp. 1–12, pl. 1 (I have not been able to find a copy of this book).

[3] Mem. du Comité Geologique, St. Petersburg, vol. 6, 1888, pp. 469 and 557, pl. 2, fig. 27.

[4] *Ibid.*, pp. 470 and 557, pl. 2, fig. 28.

[5] Zeitsch. Deutch. geol. Gesellsch., vol. 26, 1875, p. 711. Jones, Geol. Mag., dec. 3, vol. 8, 1891, p. 53, pl. 2, figs. 9, 10a, b.

specimens of Leaia, the first suggestion which came to the writer was that it was an abnormal individual of a species of that genus. But the rib is definitely rounded, not carinate, and the outline is distinctly that of a lioestherian. It may be related to the Mississippian *Leaia avonensis*, a species which strongly suggests the beginnings of the Leaiadidae. The carapaces of the Conchostraca have so few striking characteristics that their relationships will probably always be subject to individual interpretation.

Monoleiolophus unicostatus spec. nov.

Plate 3, fig. 11

Carapace oval, height slightly less than two-thirds the length. A low round-crested ridge extends from the umbo to the posterior ventral margin. It dies out at both ends, reaching neither the beak nor the margin. There are about 13 to 16 concentric ridges. A few near the beak are lirae, those near the middle are fine costellae, and the two nearest the margin are lirae. Where the concentric ridges cross the radial one there are slight depressions, producing a series of nodes in the intervals.

The holotype is 6.50 mm. long and 4.00 high.

Formation and locality: Three specimens were found by the writer in a shale above the Lower Mahoning sandstone of the Conemaugh series on the abandoned street railway grade in the western outskirts of Conemaugh, Penna. The holotype is No. 4792 M.C.Z

Family LYNCEIDAE Stebbing

Conchostraca with a carapace which lacks growth-lines.

Lynceus Müller

Not definable on the basis of the carapace alone, except as above.

Lynceus stchukini Chernyshev

Lynceus (*Limnetis*) *stchukini* Chernyshev, Journal of Geology, Institute of Geological Sciences, Acad. of Sci., Ukranian S.S.R., Kiev, vol. 7, 1940, pp. 25, 41, pl. 3, figs. 48–51.

This is probably the only known fossil belonging to this family. The surface lacks growth-lines, a family characteristic. The form is elongate ovate, the anterior end nearly twice as high as the posterior.

An interesting feature is the preservation of fragments of the antennae and a portion of a pair of posterior appendages, not definitely identified. Another unusual condition is the presence of a small patch (1 mm. in diameter) showing rounded impressions, 0.14 mm. in diameter, which Chernyshev considered to be the eggs, since they occupy the position of the ovarium in modern Lynceus.

The specimens are from the Jurassic on the right bank of the Daya River above Shevya village, Transbaikalia, Siberia.

Family LIMNADIIDAE Sars

Carapace ovate with relatively few lines of growth, sculpture absent from the intervales, and, in most genera, there is a relatively large smooth umbonal region.

It is difficult to characterize this family on the basis of the nature of the carapace, for Limnadopsis, a modern genus, is so different in shape from the other genera that exceptions have to be made. A new genus, closely allied, forms another obstacle. If the shell alone were known, it would be easy, and convenient, to split the family, but that can hardly be done so long as it is agreed that the nature of the rostrum and the telson is more important than the characteristics of the carapace.

Palaeolimnadia gen. nov.

Limnadiidae with relatively long oval carapace, large smooth umbonal region, and few growth lines. Genotype, *Estheria wianamattensis* Mitchell.

The anterior and posterior margins of the modern Limnadia make a distinct angle with the apex at the beak, whereas the carapace of Palaeolimnadia is regularly oval. The latter genus also lacks the external expression of the muscle-scar, so prominent a feature of most of the modern forms.

Palaeolimnadia wianamattensis (Mitchell)

Plate 3, figs. 7, 8

Estheria wianamattensis Mitchell, Proc. Linn. Soc. of New South Wales, vol. 52, 1927, p. 108, pl. 2, figs. 7, 8.

The carapace resembles that of *P. coghlani*, but a large specimen (3 mm. long, 2 mm. high) has only 6 or 7 growth-lines.

From the Wianamatta series, Triassic, near Glenlee Homestead on the Great Southern Railway, New South Wales.

Palaeolimnadia glabra (Mitchell)

Estheria glabra Mitchell, Proc. Linn. Soc. of New South Wales, vol. 52, 1927, p. 110, pl. 4, figs. 2, 3.

A small oval form, 4 mm. long and 2 mm. high, with only three or four concentric lirae. This is the oldest Palaeolimnadia yet known, being from the Upper Permian near Belmont, Northumberland Co., New South Wales.

Palaeolimnadia ? linguiformis (Mitchell)

Estheria linguiformis Mitchell, Proc. Linn. Soc. of New South Wales, vol. 52, 1927, p. 111, pl. 4, fig. 4.

The carapace has a large smooth umbo, but the number of concentric lirae, 18, is high for this genus. It is from the Upper Permian near Belmont, Northumberland Co., New South Wales.

Palaeolimnadia coghlani (Etheridge, Jr.)

Estheria coghlani Cox, Proc. Linn. Soc. of New South Wales, vol. 5, 1881, p. 276. (Nomen nudum.)

Estheria coghlani Etheridge, Jr., Mem. Geol. Sur. New South Wales, 1888, p. 6, pl. 1, figs. 1–5.—Mitchell, Proc. Linn. Soc. of New South Wales, vol. 52, 1927, p. 106, pl. 2, figs. 3–5.

At the time Etheridge wrote, the original specimens to which the specific name had been applied by Cox, had disappeared, but Etheridge published Cox's original drawings, which are poor. Mitchell unfortunately added nothing to Etheridge's rather vague description, but published fairly good photographs of one specimen each from the Cremorne and Dent Creek bore holes, and from surface outcrops at Glenlee. Cox's original specimens were from the Moore Park bore, Surrey Hills, Sydney. Etheridge states that the size of the valves from the Moore Park and the upper horizons at the Dent's Creek borings is remarkably uniform, varying from 1.25 to 2.00 mm. in length. Hence Mitchell's fig. 4 may be taken to represent a typical example, although not from the type-locality. This is probably a young shell, with a large smooth umbo and about eight growth lines. The other specimens are larger, but poorly preserved in the umbonal region.

According to Mitchell, this species ranges from the Estheria shales to the Wianamatta series, that is, throughout the Triassic.

Palaeolimnadia glenleensis (Mitchell)

Estheria glenleensis Mitchell, Proc. Linn. Soc. of New South Wales, vol. 52, 1927, p. 108, pl. 2, fig. 6.

Carapace with a length of 4 mm., height 3 mm., 9 or 10 growth lines. From the Wianamatta series, Triassic, near Glenlee Homestead on the Great Southern Railroad, New South Wales.

Palaeolimnadia greyi (Jones)

Estheria greyi Jones, Geol. Mag., dec. 2, vol. 5, 1878, p. 100, pl. 3, fig. 1.

This species appears to have a large smooth umbonal area, below which are about 12 costellae, but near the ventral margin there are numerous close-set lirae. The figure shows radial markings, but these, according to Jones, are due to accidental compression. The specimens were found in the upper part of the Karroo series, near Cradock, Cape Colony, So. Africa.

Pemphicyclus gen. nov.

Limnadiidae with carapace oval to sub-rectangular, with a smooth umbo, on which, in the young at least, there is a prominent node which presumably represents the position of the adductor muscle. Surface with fine relatively distant growth lines (lirae or striations), and in some cases, especially in the young, irregular radial lines between the concentric ones. Genotype, *Pemphicyclus laminatus* sp. nov.

This genus appears to be allied to the modern Limnadia, especially in the presence of an umbonal node, a feature not shown by Palaeolimnadia. Whether or not it is ancestral to Limnadia it is impossible to say. Some of the species of Limnadia lack the tubercle in the adult.

Pemphicyclus laminatus spec. nov.

Plate 3, fig. 12, plate 4, figs. 1, 2

Carapace oval, moderately convex, with about 7 to 9 slightly elevated concentric lirae. The umbonal region is smooth. The young are nearly circular, highly convex, and bear a conspicuous node at about the middle of the umbo. Even the smallest specimens show 2 or more lines of growth.

This species differs from the associated *Pseudestheria plicifera* in having finer and more widely spaced concentric markings. On internal casts, the pseudo-striations produce a superficial appearance of a sort of clapboard structure.

An interesting feature is the presence in the collection of numerous young specimens, but only a few adults. The young, up to a length of at least 3.00 mm. have a conspicuous tubercle on the umbo and slightly behind the beak. Since these young forms are so numerous it would naturally be supposed that they were larvae of *Lioestheria raaschi*, but the growth lines are more widely spaced than on the beaks of specimens of that species. Moreover, equally small individuals, with crowded growth-lines and no tubercle are present in the collection, and these are probably the young of *L. raaschi*. The tubercle must have been lost at some stage, for it is present on only a single adult in the collection. This is the holotype.

The holotype is 4.00 mm. long and 3.00 mm. high. It has 7 low costellae. One of the young specimens (M.C.Z. 4783) is 1.75 mm. long and 1.00 mm. high. It has 4 lirae.

Formation and locality: The holotype, M.C.Z. 4782, is from a locality in SE ¼, NE ¼, Sec. 34, T 22 N, R 1 W, Noble Co., Oklahoma. Paratypes, M.C.Z., 4783, and 4784 are from NW ¼, NW ¼, Sec. 34, T 22 N, and no. 4785 from the same locality as the holotype. The species is common in the general region. Collected by F. M. Carpenter and G. O. Raasch.

Pemphicyclus ortoni (Clarke)

Plate 4, figs. 3, 4

Estheria sp. Clarke, Eastman-Zittell Textbook of Paleontology, 1st ed., p. 640, fig. 1333; *ibid.*, 2nd ed. p. 734, fig. 1478.

Estheria ortoni Clarke, Report of the State Paleontologist for 1900, in Univ. of the State of New York, State Museum Report, vol. 54, No. 1, 1902, p. 109 (of the Rept. of the State Paleontologist) pl. 4, figs. 5–8.

Not *Estheria ortoni* Chernyshev, Bull. du Comité Geologique, Leningrad, vol. 47, no. 5, p. 521, pl. 37, figs. 5–7, 1928.

The adult of this species differs from *P. laminatus* in having more numerous growth lines (20), in showing traces of irregular radial markings between the outer costellae, and in having a relatively larger smooth umbonal region. The larval forms differ in having irregular radial raised lines between the costellae.

Clarke states that there are about 20 concentric growth lines on a

specimen 3 mm. long, and specimens 0.5 to 1.0 mm. long have from 3 to 7.

Clarke's concluding paragraph in his description of this species should have been taken to heart by paleontologists many years ago. ". . . we are probably encouraging misconception by permitting these ancient phyllopods to pass under the name Estheria, whose type forms all pertain to the existing fauna." He also calls attention to the fact that his species is more like a Limnadia than an "Estheria."

His specimens were from the "Lower Barren Measures" (Conemaugh) of Carrollton, Ohio.

Pemphicyclus chernyshevi spec. nov.

Estheria ortoni Chernyshev, (*nec* Clarke), Bull. du Comité Geologique, Leningrad, vol. 47, 1928, no. 5, p. 521, pl. 37, figs. 5–7.

The species which Chernyshev identified as *E. ortoni* Clarke undoubtedly belongs to the same genus, but differs in being almost as high as long, hence is almost square. The beak is subcentral, further back than in *P. ortoni*. There are 10 lirae on an adult. They are higher and sharper than in the Ohioan species, and considerably coarser.

The most interesting fact about this species is that the tubercle is retained in the adult, showing close kinship with the modern Limnadia, and also with *P. laminatus*.

Chernyshev reports that his specimens came from beds in the Donetz coal basin which are equivalent to the "Lower Barren" measures of Ohio, that is, Westphalian.

Estheriina Jones

Estheriina Jones, Geol. Mag., dec. 4, vol. 4, 1897, p. 195.

Umbonal regions swollen, the ventral portion flattened. There is an abrupt descent from one to the other. On the umbonal region the lines of growth are sharp and widely spaced, whereas on the flattened area they are numerous and close together. Genotype, *Estheriina bresiliensis* Jones.

Estheriina bresiliensis Jones

Plate 4, figs. 5, 6

Estheriina bresiliensis Jones, Geol. Mag., dec. 4, vol. 4, 1897, p. 198, pl. 8, figs. 1a-c, 2a,b,3,4,5.

As Jones has said, the umbonal and subumbonal regions are strikingly set off from the major portion of the valves, a feature to be seen to a certain extent in the modern Limnadia. Between the somewhat raised concentric lirae the surface is densely pitted. A typical specimen is 6.4 mm. long and 5 mm. high, the umbonal portion being 3.6 mm. long and 2.4 mm. high. These fossils were collected from strata of undetermined age, probably Cretaceous, near Bahia, Brazil.

Jones assigned *Cardinia freysteini* Geinitz[1] to this genus, but the writer fails to see the similarity. The same may be said of *Estheria limbata* Goldenberg,[2] which Jones has referred to Estheriina.

Estheriina expansa Jones

Estheriina expansa Jones, Geol. Mag., dec. 4, vol. 4, 1897, p. 201, pl. 8, fig. 6a, 6b.

Estheriina astartoides Jones

Estheriina astartoides Jones, Geol. Mag., dec. 4, vol. 4, 1897, p. 201, pl. 8, fig. 7, 8a, 8b.

Limnestheria Wright

Genotype, *Limnestheria ardra* Wright, Proc. Roy. Irish Acad., vol. 35, sec. B, 1928, p. 196, text figs. 1–5, pls. 24, 25.

This species occupies an unusual position among the fossil Conchostraca, for 20 specimens were found with more or less of the appendages preserved. Those best shown are the antennae, mandibles, the first pair of clasping organs, and the telson. Some of the specimens show vague traces of other organs, but give no real information.

Miss Wright points out that the appendages are similar to those of the modern Cyclestheria and Limnetis (Lynceus), except for the absence of a second pair of claspers. This characteristic is the one on which she bases the new genus Limnestheria.

Unfortunately, the carapaces of these specimens are poorly preserved. She describes the shell only as "oval, probably equi-valve, 5–6 mm. in length and 3 mm. high." She figures two fairly well preserved shells (her figs. 3 and 4). If they show the important characteristics, there is a large smooth umbonal region, larger than in any of

[1] Verstein. der Steinkohl. in Sachsen, 1855, p. 2, pl. 35, figs. 7, 7a.; *Estheria freysteini* Geinitz, Sitz.-Berichte der Naturw. Gesell.; Isis in Dresden, for 1879, p. 10, pl. 1, figs. 2a, 2A; Reed, Geol. Mag., dec. 4, vol. 4, p. 199, pl. 8, figs. 9, 10.

[2] Fauna Saraep. Fossilis, heft 2, 1877, p. 43. pl. 2, figs. 12, 14. Jones, Geol. Mag., dec. 4, vol. 4, 1897, p. 200, pl. 8, fig. 11.

the other genera known as fossils, and reminding one of the modern Limnadia and Eulimnadia. This may be taken as the generic characteristic in our present artificial classification based upon the carapaces alone.

The specimens were found in the Coal Measures in the core from a bore-hole at Ardra, in the Kilkenny district in Ireland.

Limnadopsis Spencer and Hall

Rept. Horn Exp. Centr. Australia, vol. 2, 1896 p. 328.

"Carapace compressed, . . . the union between the two halves . . . extending along the whole length of the dorsal line, which is raised into a much compressed spined keel. Lines of growth ten to fifteen clearly marked, thread-like ridges; the intervals between the more recent lines of growth continued on the dorsal keel into backward directed spines, the posterior edges of which are formed by the lines of growth, spines decreasing in size from behind forward."

No genotype was designated, but in the Zoölogical Record, volume for 1895, Crustacea, p. 32, is the statement "Limnadopsis, n.g. for *L. brunneus* n. sp. in a lagoon near Port Darwin, N. Territory, and for *L. squirei* and *L. tatei* n. spp.," etc. It happens that *L. brunneus* was the third instead of the first species described. I do not know if the above citation can be considered a designation of the genotype, but I herewith place *Limnadopsis brunneus* Spencer and Hall in that position. This species differs markedly from *Limnadopsis squirei* Spencer and Hall, in having a straight instead of a curved hinge.

Daday de Deés[1] considered *L. squirei* a synonym of *Estheria brichii* Baird, and changed the spelling of the generic name to Limnadiopsis. This is correct, but I see no objection to retaining the original form.

The generic diagnosis, so far as the shell is concerned, may perhaps be translated as follows.

Carapace suboval, with straight or curved hinge, the beak anterior, not conspicuous. Dorsal margin more or less serrate, growth-lines relatively few, further apart on the posterior than on the anterior part of the shell. The distal growth-lines recurve posteriorly on the greater part of the carapace, whereas they turn forward in the umbonal region. Genotype, *Limnadopsis brunneus* Spencer and Hall.

Members of this genus are fairly common in Australia at the present time. Their ancestors seem to have had a world-wide distribution.

[1] Ann. des Sci. Naturelles, Zoologie, ser. 10, vol. 8, 1925, p. 177.

Limnadopsis sibericensis spec. nov.

Estheria amurensis Chernyshev, (*partim*), Geol. and Prospecting Service, U.S.S.R., Bull. **49**, no. 10, 1930, pl. 1, fig. 5.

The recurved growth-lines shown in this figure are definitely of the Limnadopsis type, and the hinge appears to be serrate. It is interesting to find this early representative of the genus in the Cretaceous of Siberia.

Limnadopsis ? chilensis (Philippi)

Estheria ? *chilensis* Philippi, Tertiären und Quartären Versteinerungen Chiles, Leipsig, 1887, p. 223, pl. 50, fig. 11.

Not *Estheria chilensis* Jones, Geol. Mag., dec. 4, vol. 4, 1897, p. 289, pl. 10, figs. 4 (*nec* fig. 5).

There is considerable similarity in outline between the specimens which Jones and Philippi figured, but there can be no doubt that two species are covered by this name. As Jones suggested, Philippi's specimen strongly suggests Cyclestheria, but the beak is not so far forward as in that genus, nor is the outline so nearly circular. The few growth lines and the smooth umbo indicate that it is probably a Limnadopsis. Unfortunately neither the age nor the exact locality of the beds from which Philippi's specimen was obtained are known. Lebu, on the coast of Chili has been recorded, without supporting authority.

The *Estheria chilensis* of Jones has more growth lines than does Philippi's specimen, and is less quadrate.

Paleolimnadiopsis gen. nov.

Limnadiidae similar to the modern Limnadopsis in that the growth lines are few, widely spaced, and recurved at the dorsal margin, but differing in lacking spines on the dorsal margin, and in having a somewhat straighter hinge. There are no radial markings. Genotype, *Palaeolimnadiopsis carpenteri* sp. nov.

The generic name is suggested by the similarity to the modern Limnadopsis Spencer and Hall,[1] the chief difference in the shells being that the dorsal margin is serrated in the modern forms and smooth in the fossils. Curiously enough, the modern species of Limnadopsis are Australian. It would be interesting to know when they reached the island continent. Only one of the described fossil species from that region, *Estheria glenleensis* Mitchell[2] from the Triassic can be suspected

[1] See particularly, Daday de Deés, Annales des Sci. Naturelles, Zoölogie, ser. 8, vol. 10. 1925, pp. 175–184.

[2] Proc. Linnean Soc. New South Wales, vol. 52, 1927–28, p. 108, pl. 2, fig. 6.

of being a Palaeolimnadiopsis. Unfortunately the costellae have been inked in on the photograph, so that it is impossible to see whether or not they are reflexed at the dorsal margin.

Palaeolimnadiopsis carpenteri spec. nov.

Plate 4, figs. 7, 8, plate 5, figs. 1, 2

Individuals large, moderately convex, the region about the umbo relatively smooth, the other two-thirds of the shell showing broad low undulations. The pseudo-striae are close together on the smoother part of the shell, progressively further apart on the undulatory portion, where they follow the crests of the ridges. All of the specimens are casts, showing no trace of the shell.

There is a good deal of variation among the half dozen specimens in the collection. On some the undulations are much higher and more prominent than on others, and in such specimens they appear near the beak, so that the smooth area is small. The holotype, which is the largest specimen, 42.00 mm. long, has 10 low, broad undulations. A small specimen, 23.00 mm. long, also has 10 undulations, 9 of which are high, but the outermost is low. This seems to indicate that there was intersticial growth in the shell, which tended to smooth out the ridges with advancing age.

Measurements: The holotype of this species is the largest conchostracan known, either living or fossil. It is 42.00 mm. long and 28.00 mm. high. It is interesting to note that the genus Limnadopsis contains the largest modern conchostracans, *Limnadopsis brichii* (Baird) reaching a length of 27 mm. and a height of 20 mm.

The smallest specimen of *P. carpenteri* is 12.25 mm. long and 8.00 mm. high. It has 7 narrow concentric folds, and another broader one next to the ventral margin.

Horizon and Locality: Wellington formation, Noble Co., Oklahoma. G. O. Raasch and F. M. Carpenter, collectors. The holotype is no. 4705, and the paratypes are nos. 4706 and 4789 in the Museum of Comparative Zoölogy. The holotype is from a locality in NW ¼, SW ¼, Sec. 20, T 22 N, R 1 W, but the majority of the specimens were found in SW ¼, NW ¼, Sec. 2, T 21 N, R 1 W.

Palaeolimnadiopsis ? eifelensis spec. nov.

Estheria diensti Gross (*partim*), Senckenbergiana, vol. 16, 1934, pl. on p. 311, fig. 2 (non figs. 1, 3–6, 8, 9.)

The posterior end of this specimen is not fully shown in the figure, and the shape and recurved direction of some of the growth-lines may be due to crushing, but this specimen appears to be a Palaeolimnadiopsis. If so, it is the oldest known, for it was collected from the Lower Devonian of the Eifel district in Germany.

Palaeolimnadiopsis ? tenuipectoralis (Jones)

Estheria striata (Münster) var. *tenuipectoralis* Jones, Ann. Mag. Nat. Hist., ser. 5, vol. 12, 1883, p. 246, pl. 6, fig. 2.

The single specimen is so poorly preserved that the generic reference is unsatisfactory. The posterior margin is imperfect, but the growth lines, only partially shown in the figure, seem to be recurved at the dorsal margin, which is straight. It is from the Lower Carboniferous at Kamensk, east of the Urals.

Palaeolimnadiopsis jonesi spec. nov.

Estheria dawsoni Jones, Geol. Mag., dec. 2, vol. 5, 1878, p. 100, pl. 3, fig. 2.

Not *Estheria dawsoni* Jones, Geol. Mag., dec. 1, vol. 7, 1868, p. 220, pl. 9, fig. 15, or Geol. Mag., dec. 3, vol. 1, 1884, p. 361, pl. 12, fig. 12.

Not *Estheria* (*Euestheria*) *dawsoni* Pruvost, Terrain Houiller de Nord et du Pas-de-Calais, 1919, p. 55, pl. 24, figs. 24–28 bis, nor *Estheria* (*Euestheria*) *dawsoni* Pruvost, Mem. Mus. Royal d'Hist. Nat. de Belgique, No. 44, 1930, p. 185, pl. 10, figs. 7, 8.

Not *Estheria* (*Euestheria*) *dawsoni* Chernyshev, Bull. du Comité Geologique, Leningrad, vol. 47, 1928, no. 5, p. 519, pl. 37, figs. 1–3.

Jones gave the name *Estheria dawsoni* to a species which Dawson[1] had figured as Estheria. He had better specimens than Dawson had obtained, but from the same locality near Horton Bluff, Nova Scotia. The age, according to W. A. Bell[2] is about that of the upper part of the Pocono of the Lower Mississippian.

In 1878, Jones figured another specimen from the lowest Carboniferous east of Belhaven Bay, near Dunbar, Scotland.

This is not at all like the Nova Scotian specimens, the hinge being extended behind in a spine-like projection, so that, as Jones says, the outline of the posterior margin is sigmoid. There are from 11 to 12 concentric costellae, rather widely spaced.

[1] Acadian Geology, 1868, p. 256, fig. 58d.

[2] Trans. Roy. Soc. Canada, 1927, section 4, 1927, table opposite p. 108.

It differs from *P. carpenteri* in its much smaller size, and from the species next to be described in having fewer and more widely spaced costellae.

It is only fair to Jones to say that in 1884 he realized that the Nova Scotian and Scottish specimens did not belong to the same species.

Palaeolimnadiopsis pruvosti spec. nov.

Estheria (*Euestheria*) *dawsoni* Pruvost (*nec* Jones), Terrain Houiller de Nord et du Pas-de-Calais, 1919, p. 55, pl. 24, figs. 24–28 bis (not text figure 14). —Mem. Mus. Royal d'Hist. Nat. de Belgique, No. 44, 1930, p. 185, pl. 10, figs. 7–8.

Estheria (*Euestheria*) *dawsoni* Chernyshev, Bull. du Comité geologique, Leningrad, vol. 7, 1928, no. 5, p. 519, pl. 37, figs. 1–3.

This species has the same general shape and other characteristics as *P. jonesi*, but differs in having more numerous and more closely spaced costellae.

It has been reported by Pruvost from the lower and middle Westphalian strata in northeastern France and from the lower Westphalian of southwestern Belgium. Chernyshev's specimens were from the Westphalian of the Donetz basin.

Palaeolimnadiopsis subulata (Reed)

Estheria subulata Reed, Serv. Geol. e. Min. do. Brasil, Bol. n. 34, 1929, p. 6, 7, pl. figs. 9–11.

Reed has described from Brazil a typical member of this genus, specifically characterized by an unusually large smooth umbonal region. The length is 9 mm., height 6 mm.

The specimens are from red beds supposed to be Permian at Valloes village on the Iguassu River, Brazil.

Palaeolimnadiopsis muensteriana (Jones and Woodward)

Estheria striata var. *muensteriana* Jones and Woodward, Geol. Mag., dec. 3, vol. 10, 1893, p. 529, pl. 19, figs. 1, 2.

The hinge is straight, the posterior margin slightly sinuous, and the growth-lines recurved at the dorsal margin. There is no interstriate ornamentation. Jones and Woodward considered it to be closely allied to *Estheria striata beinertiana* Jones. It is from the Permian at Altenstadt in the Wetterau, Hesse, Germany.

PALAEOLIMNADIOPSIS ? REINACHII (Jones and Woodward)

Estheria reinachii Jones and Woodward, Geol. Mag., dec. 3, vol. 10, 1893, p. 531, pl. 19, fig. 3.

The figures of this form do not show the whole course of the growth lines but it appears to belong to the above genus. It is shorter and deeper than *P. muensteriana*, which is also found in the Permian near Altenstadt, Hesse, Germany.

ANOMALONEMA gen. nov.

Limnadiidae allied to Palaeolimnadiopsis, differing from it in having interrupted radial lirae on the carapace. Genotype, *Estheriella reumauxi* Pruvost.

The genotype is the name-member of Pruvost's "Groupe de l'*Estheriella reumauxi* Pruvost", mentioned on a previous page. The reflexed growth lines and sinuous posterior margin show clearly that it is closely related to Palaeolimnadiopsis. None of the other species mentioned by Pruvost as members of this group shows these characteristics. They are here referred to Dadaydedeesia. I have been unable to find any other species which can be said definitely to belong to the genus.

ANOMALONEMA REUMAUXI (Pruvost)

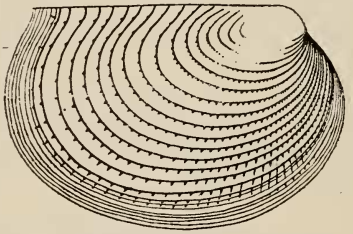

Fig. 3. *Anomalonema remauxi* (Pruvost). Genotype. A diagramatic figure, from Pruvost. x about 9.

Estheriella reumauxi Pruvost, Ann. Soc. géol. du Nord, vol. 11, 1911, p. 61, pl. 1, figs. 1–3. Terrain Houiller du Nord et du Pas-de-Calais, 1919, p. 63, text-fig. 16, pl. 24, figs. 3, 4, 35.

?*Estheriella reumauxi* Chernyshev, Annuaire de la Soc. Paleontologique de Russie, vol. 6, 1926, p. 72, pl. 7, fig. 11.

This species is so similar to *Palaeolimnadiopsis pruvosti* that it would be difficult to identify any but well preserved specimens. The length is given as from 5 to 6 mm., the height as from 3.5 to 4.5 mm. It is from the Westphalian of northeastern France.

The specimen which Chernyshev figures from Russia has a somewhat different outline, the hinge being much shorter. It was found in the Westphalian of the Donetz basin.

Anomalonema ? raricostata (Chernyshev)

Estheriella raricostata Chernyshev, Annuaire de la Soc. Paleontologique de Russie, vol. 6, 1926, p. 73, pl. 7, figs. 12–14.

The illustrations of this species are so poor that it is not possible to be sure whether or not the typical reflexed curvature of the growth lines is present. Westphalian, Donetz Basin, Russia.

Anomalonema ? densicostata (Chernyshev)

Estheriella densicostata Chernyshev, Annuaire de la Soc. Paleontologique de Russie, vol. 6, 1926, p. 75, pl. 7, figs. 15, 16.

The same remarks apply to this as to the previous species.

Family CYCLESTHERIIDAE Sars

Carapace laterally compressed, with few and indistinct growth-lines. Shell almost circular, with beaks far forward.

Cyclestherioides gen. nov.

Cyclestheriidae with the beak a bit further back than in the modern Cyclestheria. Genotype, *Estheria lenticularis* Mitchell.

So far as one can judge from the nature of the shell, both Cyclestheria and Cyclestherioides are closely related to Limnadia. If *Estheria lenticularis* were a modern form, it would doubtless be placed in the genus Cyclestheria, but since it is Permian, a more conservative course seems to be indicated.

Cyclestherioides lenticularis (Mitchell)

Plate 5, fig. 3

Estheria lenticularis Mitchell, Proc. Linn. Soc. of New South Wales, vol. 52, 1927, p. 109, pl. 4, fig. 7.

"Carapace lenticular, small, smooth; beak subanterior, incon-

spicuous; concentric striae very fine six or seven in number; interspaces increase in width as they approach the ventral margin." (Mitchell).

Newcastle coal measures, associated with various species of Glossopteris, Upper Permian, Merewether Beach, near Newcastle, New South Wales.

INCERTAE SEDIS

Rhabdostichus nov.

Conchostraca with concentric undulations separated by striae. Costellae and other surface markings absent. Beak subcentral. Genotype, *Estheria pulex* Clarke.

Except for the position of the beak, the above definition would apply to many modern estherioids. Few of them show raised concentric costellae, a depressed line or striation marking the contact of the added increment with the older part of the shell.

Rhabdostichus pulex (Clarke)

Plate 5, fig. 4

Estheria pulex Clarke, Am. Journ. Sci. Ser. 3, vol. 23, 1882, p. 476, pl. fig. 4.—Packard, Mon. No. Am. Phyllopod Crust., 12th Ann. Rept., U.S. Geol. Sur., 1883, p. 355.—Hall and Clarke, Pal. N.Y., vol. 7, 1888, p. 206, pl. 35, figs. 10, 11.

This little shell (½ mm. long and ⅔ mm. high) has six or seven concentric undulations with narrow impressed lines (striae) between. The beak is subcentral, and, apparently, the hinge slopes both backward and forward from the beak. There are no other surface markings.

One cannot be sure that it is really a conchostracan branchiopod, but it has as many characteristics of that group as do the shells of many modern "Estheriidae," and shows no features that would suggest affinities with any other group.

It was found in marine strata of the Middle Devonian (Hamilton), associated with ostracods and a Discina. Clarke thought the specimens might have been washed into the sea from a pool of fresh water temporarily formed on a flat sea shore. There is, however, no proof that there was any shore line near the locality, Hopewell, Ontario Co., New York, during Hamilton time. It may be that this is actually one of the marine ancestors of the fresh-water Conchostraca. It is certainly simple enough to serve as one.

RHABDOSTICHUS BUCHOTI (Péneau)

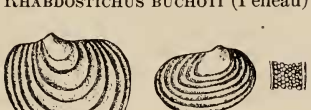

Fig. 4, a, b, c. *Rhabdostichus buchoti* (Péneau. From Péneau. x about 7.

Estheria (*Euestheria*) *buchoti* Péneau, Bull Societé Sci. Nat. de l'Ouest de France, ser. 5, vol. 6, 1937, p. 221, text figs. 2a–d.

The general configuration and small number of growth lines (6 or 7) on this form strongly suggest *Rhabdostictus pulex* (Clarke). The surface is, however, very finely reticulate as in Euestheria and Asmussia, and the shell is much longer, (4.7 mm.).

It was found in considerable numbers in the schists of Moulin de Régereau in the Armoricain Massif. The age of the beds is in doubt. Péneau was inclined to think it Silurian, because of the presence of a Bolbozoë similar to *B. anomala* Barrande, a Bohemian Silurian species. He admits, however, that it may be Devonian. The fauna is a small, rather curious one, but definitely marine, which fits well with the conditions under which *R. pulex* occurs.

SPECIES INSUFFICIENTER COGNITAE

POSIDONIA PARVA Lea

Posidonia parva Lea, Proc. Acad. Nat. Sci., Philadelphia, vol. 8, 1856, p. 77. Triassic.

POSIDONIA OVALIS Emmons

Posidonia ovalis Emmons, Geol. Rept. North Carolina., 1856, p. 323, fig. W, 1, 2;—American Geology, pt. 6, 1857, p. 40, fig. 12;—Manual of Geology, 2d ed., 1860, p. 191, fig. 166, 3.

Estheria ovata Jones (*partim*) Palaeontog. Soc., London, 1863, p. 84.

Jones, in his Monograph of 1863, placed all of the American Triassic "Estherias" in one species, and adopted Lea's name *ovata* for them. Although Phoenixville, Penna. was the type-locality for *E. ovata*, the specimens Jones figured were from the vicinity of Richmond, Virginia, and the Dan River in North Carolina. The latter was probably Em-

mons' type-locality for *P. ovalis*, although he stated that the species was common in the vicinity of Richmond. Jones had material from Phoenixville in his possession before his Monograph was published but probably did not receive it until after the drawings had been made.

Later, Jones described two new species from the Triassic of Pennsylvania, *Estheria hindei* and *E. lewisii*. After describing the latter species, he proceeded to an analysis[1] of the characteristics of *"E. ovata"* as shown in his figures of 1863. These are all on his plate 2. Although he made no statement to that effect, it is obvious that in 1890 he was doubtful about his earlier identifications of Lea's species.

A brief synopsis of his analysis, which can easily be checked by reference to his figures follows.

Fig. 26, 27. From Prince Edward, near Richmond, Va. Concentric lines, wide apart.

Fig. 28. Harding's pit, near Richmond. Concentric lines numerous and close together.

Fig. 29, 30. Concentric lines wide apart, interspaces smooth.

Fig. 31.

Fig. 32. Richmond. Reticulate interspaces, like those of *Estheria minuta*.

Fig. 33. Richmond. Small reticulation like that of *E. minuta* var. *brodiana*.

Figs. 34, 35. Dan River, North Carolina. Reticulate interspaces like those of fig. 32.

Fig. 36. Richmond. Reticulate.

Fig. 37. Dan River. Columnar interstitial ornament, like that of some Wealden specimens, and in the recent *Estheria similis*.

Fig. 38. Richmond. Interspaces filled with coarse parallel thread-like lines, one separated from another by a row of small pits.

It now appears, by his own evidence, that Jones included four genera and an undetermined number of species under the name *Estheria ovata* Lea. Figures 26, 27, 29, 30, and 31, all drawn from specimens found near Richmond, Virginia, represent a species of Pseudestheria, probably *P. ovata*. Fig. 28 is a picture of a Lioestheria, which I have described in this paper as *L. inornata*. Good specimens of both of these forms were figured, but figures 32 to 38 represent mere patches of the carapace, and we do not know what the whole shell looked like. Figures 32–36 all show polygons in the intervales. They obviously represent Euestheria, but whether one or two species it is impossible to say. Some of them are from Dan River, some from Richmond. It

[1] North American Estheridae, Geol. Mag., dec. 3, vol. 7, 1890, p. 386.

may be that this is *Estheria ovalis* but we cannot be certain, because of figures 37 and 38. In all probability they represent two species of Bairdestheria. Unfortunately one of the specimens from which they were drawn came from Dan River, the other from Richmond. Hence so far as can now be determined, *Posidonia ovalis* might be a Eustheria or a Bairdestheria. Or, if there is a slip in this attempt at elimination, it may belong to some other genus. All of which indicates the importance of properly labeling types and depositing them in a safe place.

Posidonia triangularis Emmons

Posidonia triangularis Emmons, Geol. Rept. North Carolina, p. 338, fig. V;—American Geology, pt. 6, p. 134, fig. 104.

Estheria ovata Jones, (*nec* Lea), Palaeontog. Soc., London, 1863, p. 86, text-fig. 7.

Estheria spec. indet.

Estheria sp. ind. Haynes, Science, N.S., vol. 37, 1913, p. 192, fig. 2.

The specimen which Haynes figured is an indeterminable object, possibly the scale of a fish. The growth lines enclose a smooth area which is not marginal, as it should be in a conchostracan. Only one of the "several specimens" which Haynes mentioned is identifiable. It is described on a previous page as *Pseudestheria blackstonensis.*

Estheria dawsoni Packard

Plate 5, fig. 5

Estheria dawsoni Packard (*nec* Jones), Am. Nat. vol. 15, 1881, p. 496.

Packard described, but did not figure, an "Estheria"? from the well-known post-Glacial Mallotus beds on Green's Creek, east of Ottawa, Ontario. Unfortunately, he named it for Sir William Dawson, who had already been honored when T. Rupert Jones described *Estheria dawsoni* from the Lower Carboniferous of Nova Scotia.

Dr. Thomas H. Clark has loaned me a specimen which I designate as the holotype of this species. (Peter Redpath Museum, McGill Univ. No. 6353.) It has numerous slender costellae, at least 10 per millimeter in the middle of the carapace. As Packard says, it differs from any modern "Estheria" in that "the lines of growth are much thicker, higher and closer together." There are no radial markings, but Packard seems to have seen rows of papillae for the insertion of spinules. Packard believed that it was most closely related to *Cyzicus jonesii* (Baird), a form now living in Cuba.

The specimen is crushed flat and the umbonal region is covered with clay which it is not now safe to try to remove. It is therefore impossible to determine the exact position of the beak, if one exists. One assumes, from the direction of the concentric lirae that it is a left valve and that the beak was sub-central. The form is oval, about two-thirds as high as long. The anterior and ventral outlines are moderately convex, but in the middle of the posterior outline there is a curious angle, above which the outline is straight. The growth lines follow the outline. The peculiar posterior angle arouses the suspicion that this may be a teleostean fish-scale, and Mr. William Schroeder would identify it as such. He thinks that it belonged to a herring about a foot long. This would be unusually large for a *Mallotus villosus*, but it may have come from some larger fish.

Family LEAIADIDAE nov.

Conchostraca with two or more widely divergent radial carinae, or rarely, smooth-topped ridges, the areas between which are concave. Concentric markings relatively few, consisting of lirae rather than costellae.

A typical Leaia differs so much from the other Conchostraca that one is tempted to make a separate super-family for the group. But on careful study, it seems that the only real difference of the members of this family from other "estherids" lies in the curious concavity of the areas between the radial ridges. It is probable that the family is artificial, and polyphyletic. It appears to be chiefly Carboniferous, its greatest abundance being in the Westphalian and Stephanian. Only one species is known from the Permian. This is described in this paper from a few specimens collected by Dr. Carpenter and Mr. Raasch from the Wellington formation in Oklahoma. Several of the associated fossils in these beds have a Pennsylvanian aspect. As is well known, many Pennsylvanian marine invertebrates survived in the Nebraska, Kansas, Oklahoma region for some time after the beginning of the Permian, hence it is not surprising that the same should be true of the non-marine invertebrates.

Leaia Jones (emend.)

Paleontog. Soc., London, vol. for 1862, 1863, p. 115.

Carapace rectangular to sub-rectangular, with two or three carinate

radial ridges, one of them near the dorsal margin. Genotype, *Cypricardia leidyi* Lea.

In view of the considerable variation among the various species which have been referred to the genus Leaia, it seems advantageous to restrict the name to the forms which are more or less rectangular in outline. In this group the posterior margin is approximately straight, or has a slight reëntrant just below the hinge, and in some species the growth-lines are slightly recurved at the dorsal margin, suggesting Limnadopsis, which is allied to Palaeolimnadiopsis and Anomalonema. In neither of these genera is radial ribbing present, but the shape of the posterior border, which reflects the course of the growth-lines, is about the same as in some species of Leaia. Hemicycloleaia, however, has none of these characteristics and is much more like Monoleiolophus. The Devonian Praeleaia may well be a relative of Euestheria. It is difficult to come to any definite conclusion about these fossils, since they are known from carapaces only.

Stanier was, so far as I can find, the first to point out that the species of Leaia could be divided into two groups, one with the ventral border straight or nearly straight, the other with a ventral border with rounded outline. There are numerous intergradations between the two sorts, but the typical representatives are so distinctive that it seems worth while to give a new generic name (Hemicycloleaia) to the species with the more or less semicircular outline. Pruvost's article[1] on Leaia is by far the most important contribution to the subject. He brought together the ideas of Laspeyres and Stanier, and showed how they applied to the species known at that time. If I must differ in some respects from Pruvost, a personal friend, it must be remembered that the points of view have changed a good deal in 30 years.

Pruvost adopted the suggestion of Laspeyres[2], that the angles at which the principal carinae diverge from the line of the hinge should be considered as important. The angle of the anterior carina is designated as alpha, that of the second one beta. Pruvost found that the Dinantian (Mississippian) species showed a value for α ranging between 70° and 80°, whereas those from the Westphalian had an α of about 90°, and the Stephanian species had an α of about 100° to 110°.

[1] Ann. Soc. Geol. du Nord., vol. 43, 1914, p. 254–281.
[2] Zeitsch. der Deutsch. Geol. Gesellsch., vol. 22, 1870, p. 773.

Leaia leidyi (Lea)

Cypricardinia leidyi Lea, Proc. Acad. Sci., Philadelphia, vol. 7, 1855, p. 341, pl. 4.

Leaia leidyi Jones, Paleontog. Soc., London, 1863, p. 116, pl. 5, figs. 11, 12;—Packard, 12th Rept. U. S. Geol. Sur. Territories. 1882, p. 358, fig. 24;—Jones, Geol. Mag., vol. 7, 1870, p. 219, pl. 2, fig. 7; Geol. Mag. dec. 3, vol. 1, p. 361, pl. 12, fig. 13;—Laspeyres, Zeitsch. der Deutch, Geol. Gesells., vol. 22, 1870, p. 743, pl. 16, fig. 3;—Pruvost, Ann. Soc. Geol. du Nord, vol. 43, 1914, p. 261, text-fig. 1.

Not *Leaia leidii* Dawson, Acadian Geology, 1868, p. 256, fig. 78c.

Shell sub-rectangular, outline slightly convex at front, almost straight behind. As measured on figures of the type, the angle α is 77°, β is 33°. There are about 12 lirae. The specimens were from the Mauch Chunk shale, one mile southeast of Pottsville, Penna.

Leaia laevicostata spec. nov.

Fig. 5. *Leaia laevicostata* Raymond. Holotype. x 6.

Carapace subrectangular, the height being to the length as about 8–13. Both radial ridges are rounded, slightly nodose. The anterior one is straight, α being about 90°. β is about 25°, which is unusually low. The holotype is 3.25 mm. long, 2.00 mm. high. There seem to be 7 or 8 lirae, with intervals slightly wider than themselves. Another specimen, 5 mm. long, has 14 lirae. All data on this species are approximate, for the specimens are not well preserved and the ridges are obscure. It differs from *L. leidyi* in its smoother ridges, more numerous lirae, and the greater value of α.

The holotype is from the Cheverie formation, (Mississippian) on the shore of the Avon River, opposite Horton Bluff, Nova Scotia. It is no. 9449 in the Museum of the Geological Survey of Canada and was collected by Dr. Walter A. Bell.

Leaia williamsoniana Jones

Leaia leidyi var. *williamsoniana* Jones, Paleontog. Soc., London, 1863, p. 117, pl. 1, figs. 19, 20.

Leaia williamsoniana Laspeyres, Zeitschr. der Deutsch Geol. Gesells., vol. 22, 1870, p. 743, pl. 16, fig. 3; — Pruvost, Ann. Soc. Geol. du Nord, vol. 43, 1914, p. 269, text-fig. 6.

This is a typical Leaia, rectangular except for the rounded anterior margin, the anterior carina straight, and the angle α 90°. It is from the Westphalian of Lancashire, England.

Leaia subquadrata spec. nov.

Leaia leidyi Jones (*nec* Lea), Geol. Mag., vol. 7, 1870, p. 219, pl. 9, fig. 11a-c (not figs. 12, 13, 14).

Leaia leidyi var. *salteriana* Jones 1884, (*nec* Jones 1863), Geol. Mag., dec. 3, vol. 1, 1884, p. 362, pl. 12, fig. 13.

Jones figured under this name, but did not describe, a subquadrate Leaia from the Coal Measures on Cilfach-bargoed-fawr farm, about 1½ miles southwest of Bedwelly church, Glamorganshire, Wales. Pruvost later referred it to *L. tricarinata*, from which it differs in being proportionally much higher and in having the characteristics of a true Leaia. In 1884 Jones republished the same figure, and referred the specimen to his variety *salteriana*. In this article he cites the form as occurring at Horton in Nova Scotia and includes a reference to Dawson's figure 78e, p. 256, in "Acadian Geology."

The carapace is irregularly subquadrate, three fourths as high as long, with about 14 or 15 fine lirae, which have a straight course between the first and second carinae. The angle α is about 97°, β is about 52°. The lirae are distantly spaced, as in *L. pruvosti*, but it differs from that species in having a higher value for angle α. The two forms are, however, probably closely related. The length is 5.6 mm., and the height 4.2 mm.

Leaia spec. ind.

Leaia leidyi Dawson (*nec* Lea), Acadian Geology, 1868, p. 256 (footnote), text fig. 783.

Leaia leidyi var. *salteriana* Jones 1884, (*nec* Jones 1863), Geol. Mag. dec. 3, vol. 1, 1884, p. 362 (not pl. 12, fig. 13).

The figure shown by Dawson represents a carapace similar to that of *L. subquadrata*. It has the same high form, subquadrate outline,

and about the same value for the angle α. The figure shows 10 widely spaced lirae, a smaller number than in *L. subquadrata*. The length is about 7 mm. and the height about 4 mm. Dawson's specimens came from near the Strait of Canseau, where the rocks, according to Dawson, are of the same age as those near Horton, Nova Scotia, that is, Mississippian.

Leaia paralella spec. nov.

Leaia leidyi Jones (*nec* Lea), Geol. Mag. vol. 7, 1870, p. 219, pl. 9, figs. 13, 14 (not figs. 11, 12).

Carapace subrectangular, of the form characteristic of the true Leaia. Lirae fine, distantly spaced, about 11 in number. The angle α is about 80°, β about 27°. The length is 4.6 mm., the height 2.7 mm.

It is remarkable that a species of this type should be found associated with such forms at *L. subquadrata* and *L. cymruensis*. Both of these have values for angle α which would suggest Stephanian age, whereas the present species has the angle which one finds ordinarily in Dinantian forms. It is probably closely related to *L. leidyi*, differing chiefly in the angles at which the carinae are placed.

Two specimens were figured by Jones from the Coal Measures on Cilfach-bargoed-fawr farm, about 1½ miles southwest of Bedwelly Church, Glamorganshire, Wales.

Leaia cymruensis spec. nov.

Leaia leidyi Jones (*nec* Lea), Geol. Mag., vol. 7, 1870, p. 219, pl. 9, fig. 12 (not figs. 11, 13, 14).

This is another of the forms from the Coal Measures in Glamorganshire. It has a more normal shape for a Leaia than *L. subquadrata* does. The ventral outline is somewhat convex, but the course of the lirae between the first and second carinae is straight. The lirae are closely spaced, there being 17 or 18 on the figured specimen. The length is 5.4 mm. and the height 3.5 mm. The angle α is about 100° and angle β is about 45°.

Leaia bristolensis spec. nov.

Leaia leidyi var. *salteriana* Bolton (*nec* Jones), Quart. Journ. Geol. Soc., London, vol. 67, 1911, p. 325, pl. 27, figs. 5, 6.

Judging from the figures, which are excellent, this is a real Leaia, although superficially similar to *Hemicycloleaia tricarinata* (Meek and

Worthen). The holotype is 4. mm. long, 3. mm. high, and has about 17 lirae. The angle α is about 100°, and β about 50°. The anterior carina is slightly curved, and the dorsal one prominent. It was found in Westphalian strata near Bristol, England.

Leaia pruvosti spec. nov.

Leaia tricarinata forme *minima* Pruvost (*partim*), Ann. Soc. Geol. du Nord, vol. 43, 1914, pl. 2, fig. 12 (non figs. 9–11); -Terrain Houiller du Nord et du Pas-de-Calais, 1919, p. 67, pl. 25, fig. 3, (not figs. 1, 2, 4).

This species differs from other Leaias in being shorter and higher. The angle α is 90°, β is 45°. Another outstanding feature is the width of the spaces between lirae, there being only 7 or 8 of the latter on the holotype. The length is 3.6 mm. and the height 2.6 mm.

This species somewhat resembles *L. bristolensis* Raymond although it is shorter and higher. They differ also in the course of the lirae behind the second carina. In *L. bristolensis* the lirae meet the third carina almost at right angles, although there is a suggestion of a slight backward turn. The lirae of *L. pruvosti* turn forward as they approach the third carina.

The specimen is from the lower Westphalian, zone A2, at Aniche, northeastern France.

It is named for Professor Pierre Pruvost, expositor of the nonmarine faunas of the Carboniferous of northeastern France and Belgium.

Leaia barroisei spec. nov.

Leaia tricarinata forme *minima* Pruvost (*partim*), Ann. Soc. Geol. du Nord, vol. 43, 1914, pl. 2, figs. 8, 9 (not figs. 10, 11, 12); Terrain Houiller du Nord et du Pas-de-Calais, 1919, p. 67, pl. 25, fig. 4 (not figs. 1–3).

The carapace is elongate, sub-rectangular, with nearly straight ventral margin. The anterior outline is almost semi-circular, the posterior one nearly straight. The anterior carina is curved on one specimen, straight on the other. The angle α is 90°, β about 37°. There are about 11 or 12 lirae.

The holotype, Pruvost's figure 8, is 4.2 mm. long and about 2.2 mm. high. The paratype, figure 9, is 4.0 mm. long and about 2.0 mm. high.

The holotype is from the Westphalian, zone A2, at Veille Marihaye, near Liege, Belgium. Named for Charles Barrois, famous for international personal friendships, specialized knowledge of the intricate

structure of coal fields of northeastern France and southwestern Belgium, and his broad knowledge of world-wide geology.

Leaia herriana Guthörl

Leaia herriana Guthörl, Abhandl. der Preuss. Geol. Landesanstalt, n.f., vol. 164, 1934, p. 21, pl. 3, fig. 2, text-fig. 11.

This is a Stephanian species from western Germany which in many respects resembles *Hemicycloleaia tricarinata* and *L. reflexa*. The angle α is, however, small 85°, too small for a typical Stephanian form. The ventral margin is strongly curved and 24 lirae are present on a specimen 5.20 mm. long. The anterior costa is somewhat curved.

Although the outline is intermediate between that of a Leaia and a Hemicycloleaia, the species seems to be a member of the former genus.

Leaia reflexa spec. nov.

Plate 6, fig. 1.

Carapace subrectangular, the outline moderately rounded at the front, gently convex below, and slightly reflexed behind, since the hinge projects a small distance beyond the portion of the shell immediately below it. The first and second carinae are high, the dorsal one faint. The anterior carina is curved, but the angle α is little more than 90°: β is about 30°. Just behind each of the principal carinae the shell is deeply concave. Where crossed by the lirae, the carinae are nodose. The lirae are high, sharp, about 12 in number.

The holotype is 5.25 mm. long and 3.5 mm. high.

This species resembles *Hemicycloleaia tricarinata* (Meek and Worthen), differing chiefly in having fewer and more highly raised lirae and a less curved ventral margin. It is doubtful if poorly preserved specimens could be identified satisfactorily.

Formation and locality: A rare species at various localities in the Wellington formation (Lower Permian) in Noble Co., Oklahoma. The type (MCZ 4711) was found by Dr. G. O. Raasch at a locality in SW ¼ of NW ¼, Sec. 2, T 21 N, R 1 W.

Hemicycloleaia gen. nov.

Leaiadidae with semicircular to subquadrangular outline, the two or three radial ridges rounded or carinate, much reduced in some species. Genotype, *Hemicycloleaia laevis* sp. nov.

Hemicycloleaia leavis spec. nov.

Plate 6, fig. 2

Carapace subquadrangular, anterior margin somewhat rounded, posterior one almost straight. Carinae narrow, slightly elevated. Angle α about 95°, β about 43°. Pseudostriae 11 in number. Length of holotype 7.00 mm., height 5.00 mm. The paratype is 4.00 mm. long and 3.5 mm. high.

This species is remarkable in that the height so nearly equals the length, and for the general smoothness. The specimens are casts of the interior, and show faint undulations along the middle of the valve. It was found by the writer in a shale above the Lower Mahoning sandstone of the Conemaugh series of the Pennsylvanian in a cutting on the abandoned electric line just outside the town of Conemaugh, Penna. The holotype is no. 4795 in the Museum of Comparative Zoölogy, and the paratype is no. 4799.

Hemicycloleaia salteriana (Jones)

Leaia leidyi var. *salteriana* Jones, Palaeontog. Soc., London, 1863, p. 119, pl. 1, fig. 21.

Leaia salteriana Laspeyres, Zeitsch. des Deutsch. Geol. Gesellsellsch., vol. 22, 1870, p. 744, pl. 16, fig. 5;—Pruvost, Ann. Soc. Geol. du Nord, vol. 43, 1914, p. 262, pl. 2, figs. 1–3, text-fig. 2:

Not *Leaia leidyi* var. *salteriana* Bolton, Quart. Jour. Geol. Soc. London, vol. 67, 1911, p, 325, pl. 27, figs. 5, 6.

Not *Leaia salteriana* Stanier, Ann. Soc. Geol. Belgique, vol. 38, 1911, p. 1380.

Pruvost figured a neotype of this species, Jones' original specimens having disappeared. The anterior carina is straight, and the angle α varies from 70° to 76° in various specimens. The species is from the Calciferous sandstone series, Lower Carboniferous, of Fifeshire, Scotland.

Hemicycloleaia trigonoides (Moysey)

Leaia trigonoides Moysey, Geol. Mag., dec. 5, vol. 8, p. 498, fig. 1;—Pruvost, Ann. Soc. Geol. du Nord, vol. 43, 1914, p. 264, text-fig. 3.

The carapace is small, somewhat longer than high, almost semicircular. The anterior carina is straight and the angle α about 90°.

It is from the Westphalian of Derbyshire, England.

Hemicycloleaia minima (Pruvost)

Leaia leidyi Renier (*nec* Lea), Ann. Soc. Geol. Belgique, vol. 34, 1906, p. B 58, vol. 36, p. B 161.

Leaia salteriana Stanier (*nec* Jones), Ann. Soc. Geol. Belgique, vol. 38, 1911, p. B 80.

Leaia tricarinata Pruvost, (*nec* Meek and Worthen), Compte Rendu, 12th Internat. Geol. Congress, Toronto, 1913, pp. 929, 930.

Leaia tricarinata forme *minima* Pruvost, Ann. Soc. Geol. du Nord, vol. 43, 1914, p. 267, pl. 2, figs. 10, 11 (not figs. 8, 9, 12), text-fig. 4,—Terrain Houiller du Nord et du Pas-de-Calais, 1919, p. 67, pl. 25, figs. 1, 2 (not figs. 3, 4), text-fig. 17;—Mus. Royal d'Hist. Nat. de Belgique, Mem. 44, 1930, p. 186.

Pruvost was unable to accept this as a distinct species, but named it chiefly because it was a recognizable small form which occurred over a considerable area low in the Westphalian of northeastern France and southwestern Belgium. The specimens which he considered to be the true *L. tricarinata* were found in the same region only in the upper Westphalian. I am inclined to think that at least three species are included in the *forme minima*, this notion being based on inspection of Pruvost's excellent photographs. Two of these, *Leaia pruvosti* and *Leaia barroisei* have been described on previous pages of this article.

Pruvost designated as "Types" (cotypes) the three specimens shown in his figures 10, 11, and 12, on plate 2. Here we obviously have two species, for figures 10 and 11 represent Hemicycloleaias, whereas figure 12 is that of a Leaia. The specimen shown in figure 11 is the better preserved of the two Hemicycloleaias, and it was doubtless from it that his text-figure 4 was drawn. This figure is labeled "type," which may be interpreted as meaning holotype. I so designate it.

The species, as represented by this specimen is much like *H. tricarinata*, differing in its smaller size, less convex ventral outline, and serrate lirae. It is from the lower Westphalian, zone A2, at Aniche, northeastern France.

Hemicycloleaia ashleyi spec. nov.

Plate 6, fig. 3.

Carapace elongate, rounded both anteriorly and posteriorly, and gently curved on the ventral margin. Anterior carina extremely narrow, so faint as to be overlooked on some specimens; the second is more prominent, but thread-like. The whole surface is convex, with little indication of the concavities present in most species of the Leaia-

didae. The concentric lirae, about 15 in number, are very fine, curved between the first and second carinae, not straight as in Leaia.

This is a distinctive form, but so much like *Monoleiolophus unicostatus*, which occurs in the same layers, that for a time I confused the two. In fact, I am not yet sure whether this species should be referred to the Lioestheriidae or to the Leaiadidae.

The holotype (M.C.Z. 4794) is 5.20 mm. long and 3.00 mm. high.

Horizon and locality: The species has so far been found only in a shale above the Lower Mahoning sandstone of the Conemaugh series of the Pennsylvanian in a cutting along the abandoned electric line just west of Conemaugh, Penna. It is named for Dr. George H. Ashley, long the Director of the Geological Survey of Pennsylvania, a specialist on Palaeozoic coals.

Hemicycloleaia tricarinata (Meek and Worthen)

Plate 6, fig. 4, 5

Leaia tricarinata Meek and Worthen, (*partim*), Geol. Sur. Illinois, vol. 3, 1868, p. 541, text-figs. B 1–3, (not fig. C;) —White, 13th Ann. Rept. Dept. Geol. and Nat. Hist. for 1883, 1884, p. 167, pl. 39, figs. 10–12, not 13. (Figures copied from Meek and Worthen);—Pruvost, Ann. Soc. Geol. du Nord, vol. 43, 1914, p. 265, pl. 2, figs. 4, 5, (not figs. 6, 7).

Not the *Leaia tricarinata* as identified by various European authors.

"Carapace valves moderately convex, . . . the length and height being generally about as 40 to 27, but variable . . . ; anterior outline rounded, basal margin more or less convex in outline, truncated posterior margin nearly straight . . . lateral carinae or ridges linear, well defined and extending from the beaks at an angle of about 60°, the anterior [posterior] one, which is the longer, straight and extending to the posterior basal margin, and the anterior or shorter one a little curved and passing from the beaks to the anterior basal border; surface marked by about 12 to 16 minute, very slender, regularly disposed, concentric hair-like striae [lirae] running parallel to the basal and anterior and posterior margins.

"Length of a rather large individual, 0.40 inch, height 0.27 inch. . . .

"The specimens represented by cuts B were found . . . in LaSalle county, Illinois, in the lower part of the real Coal Measures [probably Carbondale] and that represented by cut C is from a high position in the Upper Coal Measures of St. Clair County."

The specimen shown in Meek and Worthen's text-figure C is not a *Leaia tricarinata*. It is shorter, and has a straighter posterior margin.

The identification of specimens of *H. tricarinata* raises several problems. On some specimens the anterior carina is straight, on others curved, and the angle α varies from about 90° to about 100°. Figures B_1 and B_2 in Meek and Worthen's paper show a curved anterior carina and the 90° α mentioned above. Professor Stuart Weller sent to Pruvost four specimens from the neighborhood of Georgetown, Illinois, which were pictured by Pruvost on his plate 2, figs. 4 and 5. These show an angle α of about 90° and a curved anterior carina. The strata at Georgetown are of Carbondale age and these are undoubtedly the true *L. tricarinata*. Dr. J. Marvin Weller has loaned me specimens from Taylorsville, Illinois, found in a drill core 18 feet above the No. 5 coal. This would indicate an horizon in the Carbondale series (Westphalian). These specimens are flattened, so that the dorsal carina appears to be marginal. Some have straight, some curved anterior carinae.

Professor Harold W. Scott was good enough to loan me the holotype of *L. tricarinata* (Meek and Worthen's text figures 1, 3). It is beautifully preserved in a pyrite nodule along with various other specimens of the same species. It retains its natural convexity, and shows a narrow, smooth slightly concave flange between the dorsal carina and the hinge. This area is at about right angles to a plane passing between the valves. Meek and Worthen's figure B_3 is an excellent restoration. The specimen is 8 mm. long and 5 mm. high. The anterior carina is slightly curved, the dorsal one high, conspicuous, and somewhat nodose where the concentric lirae cross it. The angle α is about 90°, β is about 35°. There are 22 or 23 fine lirae.

Pruvost was of the opinion that all "Leaias" have dorsal carinae, and that the flange between it and the hinge is concealed by the flattening of most specimens. Under these circumstances, the dorsal carina seems to be the hinge. This is probably true of some species, but there is little or no opportunity to investigate the question with the material now available.

Leaia tricarinata is neither a typical Leaia nor a typical Hemicycloleaia. The outline is more or less intermediate, depending on the state of preservation. There are, however, no specimens in which the ventral outline is not convex, and none in which the course of the lirae between the first and second carinae is straight. It seems best, therefore, to use the present generic name. Pruvost grouped it with the species having suboval valves. Several species exemplify this intermediate stage between the two genera.

All of the specimens which can be definitely identified as belonging to this species are from Illinois and Indiana.

Hemicycloleaia wellerorum spec. nov.

Leaia tricarinata Meek and Worthen (*partim*), Pal. Illinois, vol. 3, 1868, p. 541, text-fig. C (non B_1, B_2).

As Pruvost pointed out, Meek and Worthen's third figured specimen has characteristics which indicate that it is not the true *L. tricarinata*. Why Pruvost referred it to *L. baentschiana* is not obvious, for it is not so high, and the angle α is considerably more obtuse, about 112°. The anterior carina is curved, the specimen is shorter and higher, and has a straigher posterior margin than does *H. tricarinata*.

The type was found at a "high position in the Upper Coal Measures of St. Clair Co., Illinois. The name is for the father and son, Stuart and J. Marvin Weller, who have done so much to elucidate the paleontology and stratigraphy of Illinois.

Hemicycloleaia haynesi spec. nov.

Plate 6, fig. 6

Leaia tricarinata Haynes (*nec* Meek and Worthen), Science, N.S., vol. 37 1913, p. 192, fig. 1.

? *Leaia baentschiania* Pruvost, Ann. Soc. Geol. du Nord, vol. 43, 1914, p. 260 270.

This species differs from *H. tricarinata* chiefly in being shorter and higher and in having the anterior carina straight instead of arcuate. The angle α varies from 90° to 100°, and there are apparently from 16 to 18 lirae, a few less than in the Illinoian species. The umbos are not well preserved, hence the count is not accurate. The angle β varies from 30° to 40°. Some specimens of *H. tricarinata* have a straight anterior carina, although it is curved on the holotype. It is probable that both *H. tricarinata* and *H. haynesi* occur in Illinois, which would explain the apparent variability of Meek and Worthen's species.

Pruvost suggested that Haynes' specimens might belong to *H. baentschiana* (Beyrich), but that species has a much more convex ventral outline.

The holotype of the species (Haynes' figured specimen) is 9.0 mm. long, 5.5 mm. high, α is 100°, β 40°, and there are about 18 lirae. A better preserved specimen from the original locality is 8.00 mm. long, 5.25 mm. high, α is 90°, β 30°, and there are about 16 lirae.

The type locality is Central Falls, near Pawtucket, Rhode Island, and the age Pennsylvanian, probably Conemaugh. The holotype is M.C.Z. No. 4803 and the paratype is M.C.Z. No. 4801.

HEMICYCLOLEAIA NORMALIS spec. nov.

Plate 6, fig. 7

Carapace somewhat semi-oval, the anterior end short, with crowded lirae, the posterior outline slightly reflexed at the hinge. The lirae are fine, rather equally spaced in the median portion of the shell. The angle α is 80°, β 30°, the length 9.50 mm., the height 6.75 mm. Only 12 lirae can be counted, but there are probably more near the beak.

Species of this type are common and it will probably be difficult to distinguish one from another. The present one has an outline similar to that of *Leaia reflexa* from Oklahoma, but α is less than 90°. It differs in the same respect from *H. haynesi*, with which it is associated. On the other hand, *H. acutangularis* from the same locality has an angle α 20° lower, and is a much more elongate form. It seems most closely allied to *H. salteriana* (Jones), but has a shorter anterior portion with more crowded lirae.

The holotype (M.C.Z., 4804), was collected by W. P. Haynes from the Mid-Pennsylvanian strata at Central Falls, near Pawtucket, Rhode Island.

HEMICYCLOLEAIA ACUTANGULARIS spec. nov.

Fig. 6. *Hemicycloleaia acutangularis* Raymond. Holotype. x 4.

Carapace elongate, rounded anteriorly and below, slightly reflexed posteriorly. The concentric lirae are so slender and ill preserved that it is impossible to count them. The angle α is 60°, β about 23°. The length of the holotype is 9.00 mm., and the height 5.25 mm.

The chief characteristic of the species, and the one which suggested the name, is the acuteness of the angles α and β. In this respect it differs from all other known Leaiadidae. The holotype and only known specimen shows the third, marginal carina, despite its flattened condition. The shape may be abnormal, because of longitudinal stretching, but this does not seem probable, for two specimens of *H. haynesi* on the same fragment of shale have their normal proportions.

The holotype (M.C.Z. No. 4802) is from the Mid-Pennsylvanian at Central Falls, near Pawtucket, Rhode Island, and was collected by Winthrop P. Haynes.

Hemicycloleaia boltoni spec. nov.

Leaia tricarinata Pruvost (*nec* Meek and Worthen), Ann. Soc. Geol. du Nord, vol. 43, 1914, p. 265, pl. 2, figs. 6, 7.

Bolton sent to Pruvost two specimens which were found in the Westphalian near Bristol, England. Pruvost figured them as *Leaia tricarinata*, and considered them to be the same species which Bolton had described as *Leaia leidyi* var. *salteriana*. It is, however, obvious from Pruvost's excellent photograph, that although this is a Hemicycloleaia, it is not *H. tricarinata*, and that it is not the same as the form which Bolton figures as *Leaia leidyi* var. *salteriana*, which is described on a previous page as *Leaia bristolensis*.

H. boltoni is like *H. tricarinata* in shape, and in having an angle α of about 90°, but has fewer and more widely spaced lirae.

Pruvost's best specimen (his pl. 2, fig. 7) which I designate as the holotype, is about 7 mm. long, 5 mm. high, and has 12, or possibly a few more lirae.

Hemicycloleaia baentschiana (Beyrich)

Leaia leidyi var. *baentschiana* Beyrich, Zeitschr. der Deutsch. Geol. Gesells., vol. 16, 1864, p. 363;—Goldenberg. Fauna Saraep. foss., vol. 1, 1873, p. 29, pl. 1, figs. 20, 21; *ibid.* vol. 2, p. 46, pl. 2, fig. 24.

Leaia baentschiana Laspeyres, Zeitsch. der Deutsch. Geol. Gesells., vol. 22, 1870, p. 744, pl. 16, fig. 2.;—Leppa, Geol. Skizze der Sarbr. Steinkohl, 1904, p. 35, figs. 2–5;—Pruvost, Ann. Soc. Geol. du Nord., vol. 43, 1914, p. 270, text-fig. 7;—Guthröl, Abhandl. der Preus. Geol. Landsanst., vol. 164, 1934, p. 17, pl. 2, fig. 5, pl. 3, fig. 1, text-fig. 9.

Leaia beanschi Waterlot (*partim*), Etude de la faune cont. du Terrain Houiller Sarro-Lorrain, 1934, p. 47, pl. 7, figs. 1–9, text-figs. 6A, B.

This species is either highly variable, or else there has been considerable latitude in the identification. According to Waterlot the angle α is 100° and the anterior rib may be either straight or curved. Many of the specimens show a strong dorsal carina. Some resemble *H. tricarinata* (Meek and Worthen), but the typical outline is strikingly different. It is found in the Stephanian in the Saar coal basin in Germany.

Hemicycloleaia wettinensis (Laspeyres)

Leaia wettinensis Laspeyres, Zeitschr. d. Deutsch. Geol. Gesells., vol. 22, 1870, p. 744, pl. 16, fig. 1;—Pruvost, Ann. Soc. Geol. du Nord, vol. 43, 1914, p. 274.

This remarkable species, from the Stephanian at Wettin, Saxony, has the largest carapace of any known member of the Leaiadidae, the length being 15 mm., height, 11 mm. The carinae are present only on the umbo. According to Laspeyres, the angle α is 110° and β about 65°.

The loss of the carinae in this form, and their beginnings in *L. laevicosta* of the Mississippian make it appear almost as if Leaia arose from some simple Pseudestherian such as *P. leaiaformis,* that the group ran its course, and reverted to a Pseudestheria again in the next stage after *Hemicycloleaia wettinensis.* Have we here an example of speciation by saltation? Experimental work seems to show that after a certain number of generations the mutants tend to return to the form of the original stock from which they were derived. Pruvost spoke of this species as "senile" and noted its resemblance to "Estheria."

Praeleaia Lutkevich

Bull. Com. Geol., Leningrad, vol. 48, 1929, p. 723, 729.

Leaiadidae with four or five radial ridges, but without one on the dorsal margin. Genotype, (here selected), *P. quadricarinata* Lutkevich.

In some respects, this genus resembles Estheriella, but the similarity is probably superficial. One of the important features of the Leaiadidae is the fact that the areas between the radial carinae are distinctly concave, which is not true of Estheriella. Moreover, the prominent radial ridges of Estheriella are grouped in the median portion of the carapace, whereas in the Leaiadidae, all are equally prominent. Middle Devonian.

Praeleaia quadricarinata Lutkevich

Praeleaia quadricarinata Lutkevitch, Bull. Com Geol., Leningrad, vol. 48, 1929, p. 724, 740, pl. 36, figs. 17a, b, 18a, b, 19a, b.

This species has four radial carinae, the first at a right angle to the hinge, or projecting a little forward. All the carinae reach the margin, and are nearly equally spaced. There are from 15 to 18 lines of growth. The specimens are from Middle Devonian marls near the junction of the Ruia and Pliusa rivers in Esthonia.

Praeleaia quinquecarinata Lutkevich

Praeleaia quinquecarinata Lutkevich, Bull. Com. Geol., Leningrad, vol. 48, 1929, p. 726, 731, pl. 36, figs. 2Da-d, 21a, b.

This species differs from *P. quadricarinata* in being more elongate and in having five carinae on each valve of the caracace. It is from the same locality.

Paraleaia gen. nov.

Leaiaidae with two carinae in addition to the dorsal one, the angle α obtuse. Between the carinae, and in front of the anterior one, are narrow radial grooves, which in some cases extend to the margin, in others are short. Genotype, *Leaia klieveri* Goldenberg.

As will be seen by the synonymy of the genotype, this form has been the subject of considerable discussion and difference of opinion. Goldenberg found it in the same beds as *Leaia baentschiana* Beyrich, and considered it as closely allied to that species, possibly a sexual dimorph. Pruvost adopted this view, in which he was followed, but somewhat cautiously, by Waterlot. The latter has given the best description. I agree, however, with Guthörl, that there is no real evidence for this view, and consider the radial furrows as distinctive features. Their arrangement seems to me to indicate that they are not due to compression, a possibility discussed by Waterlot.

Paraleaia klieveri (Goldenberg)

Leaia leidyi var. *klieveri* Goldenberg, Fauna Saraep. pt. 1, 1873, p. 24, pl. 1, fig. 22.

Leaia klieveriana Goldenberg. Fauna Saraepr. pt. 2, 1877, p. 46, pl. 2, figs. 20, 21;—Pruvost, Ann. Soc. Geol. du Nord, vol. 43, 1914, p. 273;—Guthörl., Abh. der Preus. Geol. Landsans., vol. 164, p. 19, pl. 2, fig. 6, text-fig. 10.

Leaia baentschiana Pruvost (*partim*), Compt. Rendu, 13th Int. Geol. Congress, Belgium, fasc. 2, 1922, p. 649.

Leaia baentschiana forma *klieveri* Waterlot, Etude de la Faune Cont. du Terrain Houiller Sarro-Lorraine, 1934, p. 50, pl. 7, figs. 1K, 10, 11.

This species is rather variable, not only in the number and length of the radial furrows but in the outline of the carapace. Waterlot gives the value for α as 105° to 108°, and that of β as 30° to 57°. The specimens are found in the Stephanian of the Saarbrücken area, western Germany.

SUMMARY ON THE LEAIADIDAE

As remarked on the page on which this family was described, it seems probable that Leaia-like animals arose at various times from various ancestors. It does not seem at all probable that Praeleaia is the ancestor of any of the later members of the group. It is more likely that it is in some way connected with Estheriella.

The present indications are that Leaia and Hemicycloleaia originated in Mississippian times from some pseudestherian stock, for there seems to be a transition from *Pseudestheria leaiaformis* through *Leaia laevicostata* to the typical Leaia with sharp carinae. The transition from the true Leaia to Hemicycloleaia is seen in so many species that it appears possible that the more oval forms were repeatedly evolved from the subrectangular ones.

Further collecting in the Mississippian of Nova Scotia will probably bring important evidence on the origin of Leaia. As Dr. Bell wrote me when sending the specimens, "It seems as though they are all Estherias turning into Leaias."

A third element in the picture is presented by *Hemicycloleaia ashleyi*. It is a question whether this species should be included in the family. Its only claim for admission is its possession of two sharp carinae, for it lacks the family characteristic of a depressed area between these ridges. It is obviously related to *Monoleiolophus unicostatus*, and should perhaps be placed in the Lioestheriidae rather than in the Leaiadidae. No other species of the same type has been found.

It has been shown in this study that the value of the angle α must be used with caution in determining the age of the strata in which the specimens are found. Not all the species with an angle less than 90° are Dinantian, nor are all those with an α of more than 90° Stephanian or Permian.

ALPHABETICAL LIST

An alphabetical list of the species of the Cyzicidae, Lioestheriidae, Lynceidae, Limnadiidae, and Cyclestheriidae mentioned in this paper follows. The specific name is followed by that of the genus under which it has been known, and this by the describer of the species. Following the sign of equality is the name of the genus to which the present writer would ascribe the species.

adamsi, Estheria, Jones = Erisopsis
alta, Pseudestheria, Raymond = Pseudestheria
amurensis, Estheria, Chernyshev (partim) = Orthothemos
amurensis, Estheria, Chernyshev (partim) = Bairdestheria
amurensis, Estheria, Chernyshev (partim) = *Orthothemos ovalis*
amurensis, Estheria, Chernyshev (partim) = *Limnadopsis sibericensis*
andrewsi, Estheria, Jones = ? Palaeestheria
anomala, Estheria, Jones = Palaeestheria
ardra, Limnestheria, Wright = Limnestheria
aricensis, Estheria, Jones = ? Dadaydedeesia
astardoides, Estherina, Jones = Estherina
autunensis, Euestheria, Raymond = Euestheria
belli, Erisopsis, Raymond = Erisopsis
belmontensis, Estheria, Mitchell = Pseudestheria
blackstonensis, Pseudestheria, Raymond = Pseudestheria
bresiliensis, Estherina, Jones = Estherina
brevis, Pseudestheria, Raymond = Pseudestheria
buchoti, Estheria, Peneau = Rhabdostichus
carpenteri, Palaeolimnadiopsis, Raymond = Palaeolimnadiopsis
cebennensis, Estheria, Grand'Eury = Pseudestheria
chernyshevi, Pemphicyclus, Raymond = Pemphicyclus
chilensis, Estheria, Phillipi = ? Limnadopsis
clarkei, Asmussia, Raymond = Asmussia
coghlani, Estheria, Etheridge, Jr. = Palaeolimnadia
costata, Estheria, Weiss = Dadaydedeesia
crassa, Estheria, Lutkevich = Lioestheria
dahurica, Estheria, Chernyshev = ? Bairdestheria
daja, Estheria, Chernyshev = Bairdestheria
dawsoni, Estheria, Jones = Pseudestheria
dawsoni, Estheria, Packard, not a conchostracan
densicostata, Estheriella, Chernyshev = ? Anomalonema
diensti, Estheria, Gross (partim) = Pseudestheria
diensti, Estheria, Gross (partim) = *Palaeolimnadiopsis* ? *eifelensis*
draperi, Estheria, Jones and Woodward = Orthothemos
drumni, Estheria, Guthörl = Pseudestheria
elongata, Estheria, Chernyshev = Pseudestheria
emmonsi, Pseudestheria, Raymond = Pseudestheria
eifelensis, Palaeolimnadiopsis ? Raymond = ? Palaeolimnadiopsis
exigua, Estheria, Eichwald = Euestheria
expansa, Estherina, Jones = Estherina
forbesii, Estheria, Jones = Euestheria
faveolata, Estheria, Chernyshev = ? Pseudestheria
freysteini, Estheria, Geinitz = ?
frikiensis, Estheria, Grabau = Pseudestheria
geinitzii, Estheria, Jones and Woodward = Pseudestheria

geinitzii, grebeana, Estheria, Jones and Woodward = *Pseudestheria grebeana*
glabra, Estheria, Mitchell = Palaeolimnadia
glenleensis, Estheria, Mitchell = Palaeolimnadia
greyi, Estheria, Jones = Palaeolimnadia
heckeri, Estheria, Chernyshev = Pseudestheria
hindei, Estheria, Jones = Pseudestheria
inornata, Lioestheria, Raymond = Lioestheria
intermedia, Estheria, Chi = Bairdestheria
ipsviciensis, Estheria, Mitchell = Pseudestheria
jonesi, Palaeolimnadiopsis, Raymond = Palaeolimnadiopsis
kansuensis, Estheria, Chi = Bairdestheria
karpinskiana, Estheria, Jones = ? Bairdestheria
kotahensis, Estheria, Jones = Bairdestheria
kryshtofovichi, Estheria, Chernyshev = ? Pseudestheria
lallyensis, Estheria, Depéret and Mazeran = Lioestheria
laminatus, Pemphicyclus, Raymond = Pemphicyclus
lata, Estheria, Mitchell = Pseudestheria
laxitecta, Estheria, Jones = Euestheria
laxitecta, Estheria, Sandberger = *Euestheria laxitecta*
leaiaformis, Pseudestheria, Raymond = Pseudestheria
lenticularis, Estheria, Mitchell = Cyclestherioides
lewisii, Estheria, Jones = Pseudestheria
limbata, Estheria, Goldenberg = Pseudestheria
linguiformis, Estheria, Mitchell = ? Palaeolimnadia
lualabensis, Estheria, Lariche = Estheriella
mangaliensis, Estheria, Jones = Euestheria
mangaliensis pennsylvanicus, Estheria, Wanner = *Pseudestheria pennsylvanica*
mathieui, Estheria, Pruvost = Lioestheria
mawsoni, Estheria, Jones = Bairdestheria
membranacea, Estheria, *auct.* = Asmussia
membranacea, Asmussia, Pacht = Asmussia
middendorfii, Estheria, Jones = Bairdestheria
minuta, Estheria, von Zieten = Euestheria
minuta brodieana, Estheria, Jones = *Euestheria brodieana*
minuta karpinskiana, Estheria, Jones = ? *Bairdestheria karpinskiana*
molesta, Pseudestheria, Raymond = Pseudestheria
multicostata, Estheria, Emmons = Pseudestheria
multilineata, Estheria, Jones = Dadaydedeesia
multistriata, Estheria, Reed = Orthothemos
murchisoniana, Estheria, Jones = Asmussia
murchisoniae, Estheria, Jones = Bairdestheria
nengkiangensis, Estheria, Chi = Bairdestheria
neotropica, Estheria, Reed = Orthothemos
nodosocostata, Estheria, Giebel = Estheriella
novacastrensis, Estheria, Mitchell = Pseudestheria

obenaueri, Estheria, Guthörl = Pseudestheria
obliqua, Estheria, Mitchell = ? Pseudestheria
oblonga, Estheria, Kratow = Dadaydedeesia
orientalis, Eichwald = *Bairdestheria middendorfii*
ortoni, Estheria, Clarke = Pemphicyclus
ovalis, Estheria, Emmons = ?
ovalis, Orthothemos, Raymond = Orthothemos
ovata, Estheria, Jones (partim) nec Lea = *Pseudestheria emmonsi*
ovata, Estheria, Jones (partim) nec Lea = *Lioestheria inornata*
ovata, Posidonia, Lea = Pseudestheria
peachi, Estheria, Jones = Pseudestheria
plicata, Estheria, Lutkevich = Pseudestheria
plicifera, Pseudestheria, Raymond = Pseudestheria
posidomyoides, Estheria, Chernyshev = Bairdestheria
progrebovi, Estheria, Lutkevich = Asmussia
pruvosti, Palaeolimnadiopsis, Raymond = Palaeolimnadiopsis
pulex, Estheria, Clarke = Rhabdostichus
raaschi, Lioestheria, Raymond = Lioestheria
radiata, Estheria, Salinas = Dadydedeesia
raricostata, Estheriella, Chernyshev = ? Anomalonema
regularis, Estheria, Reed = Orthothemos
remauxi, Estheriella, Pruvost = Anomalonema
reinachii, Estheria, Jones and Woodward = Palaeolimnadiopsis
reticulata, Estheria, Chernyshev = ? Bairdestheria
rimosa, Estheria, Goldenberg = Pseudestheria
rugosa, Pseudestheria, Raymond = Pseudestheria
sibericensis, Limnadopsis, Raymond = Limnadopsis
simoni, Estheria, Pruvost = Pseudestheria
sinensis, Estheria, Chi = Bairdestheria
sinkiangensis, Estheria, Chi = Bairdestheria
sinuata, Estheria ?, Lutkevich = *Asmussia progrebovi*
stchukini, Lynceus (Limnetis), Chernyshev = Lynceus
stockmansi, Estheria, Mailleux = ? Euestheria
stowiana, Estheria, Jones = *Orthothemos draperi*
striata, Estheria, Goldfuss and Münster = Lioestheria
striata muensteriana, Estheria, Jones and Woodward = *Palaeolimnadiopsis muensteriana*
striata tenuipectoralis, Estheria, Jones = ? *Palaeolimnadiopsis tenuipectoralis*
subcircularis, Pseudestheria, Raymond = Pseudestheria
subquadrata, Estheria, Sowerby = Bairdestheria
subulata, Estheria, Reed = Palaeolimnadiopsis
tegulata, Estheria, Jones = Dadydedeesia
tenella, Estheria, Bronn = Pseudestheria
tenuipectoralis, Estheria, Jones = ? Palaeolimnadiopsis
tessellata, Estheria, Jones = Erisopsis

transbaikalica, Estheria, Chernyshev = Bairdestheria
trapezoidalis, Estheria, Kratow = Dadaydedeesia
trigonellaris, Estheria, Mitchell = Pseudestheria
unicostatus, Monoleiolophus, Raymond = Monoleiolophus
wianamattensis, Estheria, Mitchell = Palaeolimnadia
youngi, Estheria, Jones = Pseudestheria

SYNOPTIC TABLE OF THE GENERA OF FOSSIL CONCHOSTRACA

It will probably assist in understanding the classification here adopted, and also help in the identification of fossils, to bring together brief characterizations of the various families and genera.

Family CYZICIDAE Stebbing

Shell thin, laterally compressed, with numerous distinct growth-lines, and in some, other surface sculpturing. Mesozoic to Recent.

Bairdestheria Raymond

Cyzicidae with irregular radial striations and lirae in the intervales between growth-lines or costellae. Jurassic to Recent.

Family LIOESTHERIIDAE Raymond

Conchostraca with numerous concentric costellae or costae, and, in rare instances, radial or polygonal sculpture. Devonian to Cretaceous.

Lioestheria Depéret and Mazeran

Lioestheriidae with surface of carapace covered with close-set costellae, with extremely narrow intervales. Devonian to Triassic.

Erisopsis Raymond

Lioestheriidae with numerous concentric costellae, the axis of the carapace markedly oblique to the hinge. Carboniferous.

Asmussia Pacht

Lioestheriidae with straight hinge, subcentral beak, and reticulate sculpture in the intervales. Devonian.

Orthothemos Raymond

Lioestheriidae like Asmussia, but without reticulate sculpture. Permian ? to Cretaceous.

Euestheria Depéret and Mazeran

Lioestheriidae with oval form, anterior beak, concentric lirae or costellae, and reticulate sculpture in the intervales. Devonian ? to Triassic.

Pseudestheria Raymond

Lioestheriidae with carapaces of various forms. The intervales between the lirae, costellae, or costae are punctate. Devonian to Triassic.

Palaestheria Barnard

Lioestheriidae with a large smooth umbonal region. Costellae numerous, with punctate intervales. Lower Cretaceous.

Estheriella Weiss

Lioestheriidae with radial costae crossed by concentric costellae or lirae. Triassic.

Dadaydedeesia Raymond

Lioestheriidae with radial lirae crossing the whole or part of the carapace. Westphalian to Triassic.

Monoleiolophus Raymond

Lioestheriidae with a single diagonally directed radial ridge. Westphalian.

Family LYNCEIDAE Stebbing

Conchostraca without growth lines on the carapace. Jurassic to Recent.

Lynceus Müller

Not definable on the basis of the carapace alone. Jurassic to Recent.

Family LIMNADIIDAE Sars

Carapace with relatively few growth-lines, and, in most genera, a large smooth umbo. Devonian to Recent.

Palaeolimnadia Raymond

Limnadiidae with smooth umbo, few growth-lines, and no externally visible muscle-scar. Permian to Triassic.

Pemphicyclus Raymond

Limnadiidae with an umbonal tubercle, at least in the young. Westphalian to Permian.

Estherina Jones

Limnadiidae with a swollen circum-umbonal region abruptly separated from a less convex ventral area. Cretaceous ?

Limnestheria Wright

Limnadiidae with one instead of two pairs of claspers. Westphalian.

Limnadopsis Spencer and Hall

Limnadiidae with straight, serrate hinge and growth-lines which turn backward close to the dorsal margin. Cretaceous to Recent.

Palaeolimnadiopsis Raymond

Limnadiidae similar to Limnadopsis, but without serrations on the hinge. Devonian ? to Permian.

Anomalonema Raymond

Limnadiidae with a carapace like that of Palaeolimnadiopsis, but with discontinuous radial lirae. Westphalian.

Family CYCLESTHERIIDAE Sars

Carapace almost circular, with few growth-lines. Triassic to Recent.

Cyclestherioides Raymond

Cyclestheriidae in which the beaks are not quite so far forward as in Cyclestheria. Triassic.

Family unknown

Rhabdostichus Raymond

Carapace with concentric undulations separated by incised growth-lines. Beak subcentral, hinge curved. Silurian ? to Devonian.

Family LEAIADIDAE Raymond

Conchostraca with two or more widely divergent radial carinae or ridges, between which are concave areas. The concentric markings are lirae. Devonian to Permian.

Leaia Jones

Leaiadidae with two or three radial carinae or ridges and a nearly straight ventral outline. Dinantian to Permian.

Hemicycloleaia Raymond

Leaiadidae with semicircular to subquadrate outline, with two or three radial ridges, rounded or carinate, much reduced in some species. Dinantian to Westphalian.

Praeleaia Lutkevich

Leaiadidae with five or six radial ridges. Middle Devonian.

Paraleaia Raymond

Leaiadidae with radial grooves in addition to the three radial carinae. Stephanian.

CAMBRIAN CONCHOSTRACA

Ulrich and Bassler have published a monograph on the "Cambrian Bivalved Crustacea of the Order Conchostraca," Proc. U.S. Nat. Mus., vol. 78, 1931, pp. 1–130, pls. 1–10. The specimens they described are undoubtedly bivalved Crustacea, but it is a question whether any of them are Conchostraca. Most of the species are arranged in three families, the Bradoriidae Matthew, the Beyrichonidae Ulrich and Bassler, and the Indianidae Ulrich and Bassler. A few were assigned to the Limnadiidae Baird. All members of the first three families are small, ostracod-like, but differ from true ostracods in having a less calcareous shell. Most of them seem to have an anterior rather than median muscle scar and the valves seem to be united at the hinge. The differences from the Conchostraca are even more marked than those in which they fail to reach the requirements for the Ostracoda. Many show an ocular tubercle, which is unknown in the Conchostraca, and none of them shows lines of growth. It is true that this latter feature is a characteristic of the Lynceidae, but it is a far cry from the Cambrian to the first appearance of the true Lynceidae in the Mesozoic. The Bradoriidae have an ocular tubercle, the Beyrichonidae have various ridges and nodes, unlike anything known in the Conchostraca. The Indianidae are somewhat more conchostracan-like, but lack growth-lines and have a decidedly ostracodan habitus. The writer has already commented on this group[1] and offered for them the ordinal name Bradorina, with the suggestion that they were probably the ancestors of the Ostracoda.

Some of the species which Ulrich and Bassler referred to the Limnadiidae may be conchostracans. *Leperditta curta* Matthew, which is not the genotype, and *Fordilla troyensis* Barrande (incidentally Fordilla is Barrande's genus, not Walcott's) both show growth-lines, and, technically, I do not see any way of excluding them from the Lioestheriidae. Possibly they are ancestors of the Conchostraca, but until Upper Cambrian, Ordovician, Silurian, and Lower Devonian connecting links are found it is probably wise to leave them in their present uncertain position.

GEOLOGIC AND GEOGRAPHIC DISTRIBUTION

This preliminary survey indicates that the Conchostraca can be made to serve a useful purpose in the correlation of fresh-water de-

[1] Bull. Mus. Comp. Zoölogy, vol. 76, 1935, p. 220, 228.

posits, strata which in general are devoid of easily identified invertebrate fossils. The writer does not pretend to have reached final conclusions about anything. He will be satisfied if he has stirred up interest in the group. Many paleontologists in many lands will have to study the species more carefully before their real significance can be ascertained.

A few things seem to stand out rather clearly. A modern genus, Bairdestheria, appeared as early as the Jurassic, and with the exception of one species in South America, seems to have been Eurasian, extending from Scotland to China. Another modern genus, Limnadopsis, appeared in the Cretaceous of Siberia, and is perhaps represented in South America. Lynceus is, curiously enough, reported from the Jurassic of Siberia, making a total of three modern genera which have fossil species. Cyclestherioides, from the Triassic of Australia is so like the recent Cyclestheria that some may feel that it is a synonym of that genus. Another Triassic Australian genus, Palaeolimnadia also gives a foretaste of the modern conchostracon fauna. It appeared as early as the Permian, and is South African as well as Australian.

Some of the Paleozoic genera have species which persist into the Triassic, but none into the Jurassic, so there is no great overlap of the really ancient and modern faunas. The age of the oldest conchostracean can not be definitely stated. Pineau thought that the French *Rhabdostichus buchoti* was Silurian, but it may well be Middle Devonian. *R. pulex* Clarke is certainly Middle Devonian. Lioestheria and Asmussia have been reported from the Middle Devonian of Esthonia, Euestheria and Pseudestheria from the Lower Devonian of Belgium and the Eifel district of Germany respectively. The writer is not familiar with the Devonian sequence in either Esthonia or the Belgian-German region, but has considerable confidence that the ages as given are correct. Asmussia is found in the Middle Devonian of New York, and the Upper Devonian of Livonia and Scotland. It appears to be a good Devonian index fossil. The evidence, so far as it goes, seems to indicate that the real conchostracans descended from some of the bivalved crustaceans of the Cambrian and Ordovician, and like so many other animals, got into fresh waters in late Silurian or early Devonian times. The genus Rhabdostichus appears to have remained in the original marine environment.

Lioestheria has a long range, Middle Devonian to Triassic, and but few species. As a genus it probably will not be of much use, but individual species may be important, as seems to be the case in the Carboniferous in France, Belgium and Germany. The general range is

north European, but a species is known from China, and two from the United States.

Erisopsis is another unimportant genus, being known only from the Carboniferous of Great Britain and Nova Scotia. Limnestheria, although zoölogically most interesting, is not identifiable on the basis of the carapace.

Pseudestheria can probably be made more useful by more careful study. As here used, it includes a great many species, most of which have few distinctive characteristics. The range is from the Lower Devonian to the Triassic. In North America most of the described species are from the Permian and Triassic, although there are three in the Mississippian. There is reason to believe that there are many undescribed forms in the Pennsylvanian. The oldest species are two from the Lower Devonian of Germany, and the Mid-Devonian of Esthonia has produced one. There are two species in the Dinantian of Scotland and three in strata of about the same age in Nova Scotia. Three species are known from the Westphalian of England, France, Germany and Russia, one of them, *P. simoni* Pruvost, being reported from all four countries. Only two species are known from the Stephanian, both from Germany. A single Carboniferous ? form is known from South America. The greatest abundance of the genus is in the Permian and Triassic. Two species are now known from Oklahoma and Kansas, six from Germany, one of them being found also in France, one from China, and five from Australia. All of these are Permian. From the Triassic we have four species in eastern United States, three in Siberia, and one in Australia.

Dadaydedeesia ranges from the Westphalian to the Triassic. There is one species from the Westphalian of Scotland and possibly one in the Carboniferous of Peru. Two are known from the Permo-Carboniferous of Russia, and two from the Triassic, one of them in Sicily, the other from the Malay region.

If *E.*? *stockmansi* (Mailleux) really belongs to Euestheria, this genus has as long a range as Pseudestheria. Although there are few species, they are widely distributed and definitely identifiable, hence it is an important genus. Curiously enough it has not yet been recognized in North America. So far, there is one doubtful species from the Lower Devonian of Belgium, one each from the Permian of France and Russia, three from the Triassic of the general region of Great Britain, France, and Germany, and one which has been reported from the Triassic of India and South America. Another South American species is of unknown age.

Palaeolimnadiopsis is another genus which bids fair to be important in correlation because of its wide distribution, and now that its characteristics have been pointed out, ease of identification. The geological range is definitely Dinantian to Permian, the one Lower Devonian species from Germany being only provisionally assigned to this genus. Two species are known from the Lower Carboniferous, one each in Siberia and Scotland. Another ranges from France and Belgium to Russia in the Westphalian, and two species are known from the Permian, one from Oklahoma and the other from South America.

A related genus, Anomalonema, is, so far as known, restricted to the Westphalian of France and Russia.

The curious Pemphicyclus has a widespread distribution, but so far, only three species. Two of these are Westphalian, one in Ohio and one in Russia. The third is from the Permian of Oklahoma. Monoleiolophus is known from the Westphalian of Pennsylvania only.

I took up first the genera which are represented in the present-day fauna, then those which range from the upper Paleozoic into the Triassic. We may now turn our attention to the genera confined to the Mesozoic. No one of these has yet been found in North America.

Estheriella is confined to the Triassic of Germany and the Belgian Congo. It is easily identifiable and useful.

Orthothemos may be represented in the Permian, for there are three species in Brazil which are recorded as "Permian or Triassic." I am inclined to think that the beds are of the latter age. There is one species from the Triassic of South Africa, and one from the Upper Cretaceous of Siberia.

Estheriina is confined to strata supposed to be of Cretaceous age in Brazil, and Palaeestheria is found in the Lower Cretaceous of South Africa, and possibly in England.